DISEASES OF OCCUPATION

THOMAS OLIVER

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FROM THE LEGISLATIVE, SOCIAL, AND MEDICAL POINTS OF VIEW

BY

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PREFACE

IN "Diseases of Occupation" I have endeavoured to place before the general and professional reader important facts dealing with the effects of industries upon health. The subject is one which within the last few years has attracted, and in the future is still likely to attract, considerable attention. The health of the nation must be viewed from all standpoints, and as the working-classes form the largest proportion of the population the conditions under which they labour call for thoughtful study. I am hopeful that this book will prove useful to Members of Parliament, to all persons interested in schemes for social betterment, to medical officers of health, and to members of the medical profession generally.

To the authorities at the Home Office and especially to Dr. Whitelegge and Dr. T. M. Legge I take this opportunity of acknowledging the great assistance I have received from the Annual Reports of the Chief Inspector of Factories. My thanks are due to M. Le Clerc de Pulligny, of the Ministère du Travail, Paris, for his unvarying kindness and his genial companionship in my visits to French factories; also to Mr. I. H. L. Van Deinse, of the Netherlands Factory Department, and to Dr. G. Waller, of Amsterdam. To Professor Bedson and Mr. Belger, of the Armstrong College, Newcastle-upon-Tyne, and to Drs. R. A. Bolam and Alfred Parkin I am indebted for help always cordially given.

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NEWCASTLE-UPON-TYNE

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INTRODUCTORY

THE subject of Diseases of Occupation is so intimately associated with the operation of the factory laws, that in order to study the one we must know something of the other. Factory legislation has been in the main devised to protect the health of the workpeople and to safeguard their interests.

It is a far cry from 1802, the date of the rise of factory legislation in this country, to the passing of the Workmen's Compensation Act in 1906. Within these years are included all that is known of factory legislation and what it has accomplished. Before the dawn of the eighteenth century the Industrial Revolution had already altered the conditions of life and labour in Great Britain. The substitution of steam for water power further changed those conditions, so that the health of the workpeople necessarily became a matter of State concern and State control. Labour flocked to where machinery was most active. Since then may be dated the rise of modern towns and the depletion of rural areas. It was soon found that machinery could be worked by young and, comparatively speaking, unskilled hands, hence came the demand for women's and children's labour. Factory legislation at its inception was in the main concerned with those who could not take care of themselves. The exploitation of child labour is a harrowing story, and one of the dark spots on the page of the industrial history of our country. It is to the credit of Great Britain that she was the first to move in

the matter, and thus became the pioneer of industrial legislation. Since then decade after decade has witnessed a succession of Factory Acts and Labour Laws based upon experience and necessity. It might have been expected that at the end of a century of experience and progress industrial evolution would have reached such a degree of excellence and attained to such a standard of hygienic perfection that little more would require to be done. Not so, however, for the subject is endless. Each succeeding decade brings its own problems for solution, and each new invention imposes its own special trials upon producers. Child labour was fostered by parental greed and poverty, and was encouraged by employers. Although Great Britain has, practically speaking, abolished the iniquity, child labour still lingers in several of our home industries, and is not unknown in other countries. It is only within the last quarter of a century (1886), for example, that the first Factory Act was passed in the State of New York. There, as here, factory legislation began with child labour and female labour questions, and the compelling agents were the working men's trades unions and philanthropic societies. The reproach is sometimes levelled at trades unions that their interference with children's and women's labour has not been altogether disinterested, since by raising the age for commencing work they have diminished the numbers of children employed, and by checking female labour they have kept up the standard of wages and given more work to men. In the United States there is a greater tendency to bring labour questions within the range of politics than in Great Britain. Organised labour and capital have more power there than here. By the Factory Act of 1886 no child was allowed to work in New York State under thirteen years of age; since then the minimum age has been raised to fourteen. The drawbacks to child labour are that children are deprived of leisure and freedom in the open air, and are subjected to a monotonous life when they ought to have variety. The physical effects are those of degeneracy, as seen in stunted growth and impaired nutrition, while of the moral effects illiteracy and its consequences are the more immediately apparent.

Factory legislation has been a gradual restriction of the freedom of the individual and of his subjection to State control. The events which stand out prominently in the industrial legislation of last century are, in addition to the curtailment of children's and women's labour, shortening of the hours, improvement of the conditions under which labour generally is carried on, hygiene of dangerous trades, restriction of the power of employers, and the transference of this power to organised labour. In factory work individualism is subordinated to general requirements. Theoretically there is nothing to prevent a man in his individual capacity working as long as he chooses, but there is no place for such personal action in the corporate life of a factory. The conditions do not admit of this. It is not maintained, for example, that by working longer than eight hours a day a man's health is injured, for experience proves the contrary, but it is held that no employer has the right to utilise the whole of the working part of a man's day, and thus deprive him of the leisure to which he as a human being is entitled. Since his whole nature has to be developed, it is claimed that the intellectual, moral, and physical powers of man cannot be developed if the hours of employment are too long, the work too hard and of a grinding nature. Nor must the hours of labour be the same for all trades. There are some, such as the textile industries, work in shipbuilding yards and iron works, coal mining, and several artisan trades, in regard to which a common basis of agreement can be arrived at as to whether the number of hours of work should be eight or nine. In trades that are dangerous to health the hours should not be long; and in the textile industries as the speed of machinery is quickened and the nervous tension upon the worker becomes greater the hours of labour should be proportionally reduced.

Shortening of the hours of work per day and the Saturday afternoon holiday have given the working classes more leisure, while improved conditions of labour in factories, fencing of machinery and hoists, abolition of night work for women and children, better provision of sanitary conveniences for the workers, and better education generally have done

much to raise the working classes to a higher platform of comfort as well as to one of discontent. It was apparent that the conditions of labour that prevailed before the passing of the first Factory Act could not be allowed to continue. There was a waste of human life which had to be checked and a physical degeneracy and ignorance which had to be stopped. No tongue can tell the saving of human life that has been effected by the Factory Acts. At present each fatal accident is carefully investigated, and the circumstances attendant upon each death in a trade believed to be dangerous to health are carefully sifted so that further fatalities may be averted. These precautionary methods have only been arrived at as a result of the death of many poor and unknown men and women whose lives were sacrificed that the life of others might be saved.

Industrial problems in their medical aspect not only concern society, in many instances they control the future of the race, as witness the employment of women during pregnancy and after confinement, also the baneful effects of lead upon motherhood. All work should ennoble, and yet there are certain trades that tend more to degrade man than raise him, as witness the work of the iron puddler. The cheerless days, too, spent in a textile factory amid the din of machinery, and the monotonous character of the work, are not such as of themselves to quicken the intellect and promote the higher interests of life. Is it not rather that they tend, through the strain they cause, to encourage a craving for that form of recreation which seeks an outlet in excitement and pleasure, and, on the other hand, to dishearten men and women who, as factory operatives, feel that they cannot rise to a higher occupation than that of minding machinery? The despotism of some branches of modern labour is overpowering. Factory legislation has done something to minimise this. The present age is marked by social, benevolent, and parliamentary schemes which are meant to dispense industrial justice and to provide greater personal opportunities. To be of helpful service factory legislation must be progressive and keep pace with the industrial problems special to each succeeding age.

The Rise and Progress of the Factory System

The Peel Act of 1802 was passed to preserve the health and morals of apprentices and others employed in "cotton and other mills and factories"; the rooms of the factories were to be washed with quicklime and water twice a year, night work was prohibited, the hours of work were to be twelve per day, the apprentices were to be instructed in reading, writing, and arithmetic every working day for the first four years, and in the principles of the Christian religion on Sunday. The factories and mills were to be visited by a justice of the peace and by a clergyman. Although not a Factory Act in the usual acceptation of the term, but simply an extension of the Elizabethan Poor Law relating to parish apprentices, and therefore likely to fall short of the actual requirements of the time, it was something to have succeeded in getting a few of the principles of factory legislation recognised, such as the limitation of the hours of work. The Bill passed without serious opposition from the manufacturers. It was otherwise when, later on, fresh factory legislation was attempted. In 1816, on Sir Robert Peel's proposition, Parliament caused an inquiry to be made into the condition of the factory population, and three years afterwards powers were conceded to the Government to limit the age at which children should be admitted into factories. When in 1833 Lord Ashley inaugurated the industrial and social reforms with which his name is associated, and by which it was sought to limit the working hours of children under thirteen to eight hours a day, and girls under eighteen to twelve hours a day, employers and several members of the House of Commons urged that Parliament was exceeding its duty in attempting to restrict the hours of labour. At this period the infant death-rate was high. One half of the children born in Manchester died under three years of age, and in factory towns the youthful population was physically worn out before manhood. Four inspectors had been appointed to see that the factory laws were obeyed throughout the country. Power was given to these Government officials to enter factories at any hour and to examine the workers. The employ-

ment of children under eight years of age was prohibited, and women's labour restricted by the 1844 Act. The following year witnessed the passing of Lord Ashley's Print Works Act. A demand for shorter hours of labour was also raised. In 1847 the Ten Hours' Bill was passed, and by it the working time for women and children was restricted to ten hours a day; it was also arranged that the working day was to be the period between 5.30 a.m. and 8 p.m. In 1854 the fencing of all shafts was made a requirement, but not without considerable opposition from a section of employers. The Act of 1853 limited the working time for children to the period between 6 a.m. and 6 p.m. In 1864 certain trades were scheduled as unhealthy, and regulations were issued bearing upon ventilation. Under the 1864 Act were included earthenware and other manufactures. Removal of dust by fans was required by the Act of 1867 both in factories and workshops. Three years later bleaching and dye works were brought within factory law. The Act of 1878 forbade children to work in certain processes of white lead manufacture. This was the first Consolidating Act. It was passed after an exhaustive inquiry by a Royal Commission, and was followed by a series of Amending Acts: that of 1883, in which were embodied Special Rules for white lead factories and bakehouses; of 1891, in which were included Special Rules for dangerous trades, notification of accidents, and the abolition of the employment of children under eleven years of age; of 1895, whereby laundries were brought within the sphere of factory inspection, and rules were made applicable to docks; while the Act of 1897 dealt mainly with cotton, cloth, and other factories.

Until 1891 workshops had not been included under all the provisions of the Factory Acts; the difference between the two places lay in the use of motive power in factories. The Factory Act of 1891 repealed the special exemption enjoyed by women's workshops and extended sanitary regulations to workshops in which only adult men are employed. The main "design and object" of this Bill "was to bring all workshops and factories up to the same sanitary level." To local sanitary authorities was entrusted

the supervision of the sanitary condition of the workshops, and although to give this effect special inspectors of workshops for certain large towns were appointed it cannot be said that the dual control was an unqualified success, owing to the fact that local authorities too frequently shirked their responsibilities. By the Act of 1901 increased powers were given to local authorities, and medical officers of health were called upon to keep registers of the workshops in their districts and to report upon them annually.

It is required by the factory laws that all dangerous machinery shall be fenced, safety valves and steam gauges be provided on steam boilers, that boilers be examined by an expert and reported upon once in every fourteen months, and that no machinery in a factory shall be cleaned by a child when the machinery is in motion, nor shall a young person clean any dangerous part of mill gearing. Women are also forbidden to clean mill gearing while the machinery is in motion. Fire escapes must be provided. At present no child under twelve can be employed in a factory or workshop. The Act of 1878 allowed children to be employed at the age of ten; the Act of 1891 raised the age to eleven; and now no child can be employed under twelve. To the Home Secretary has been given greater power for the regulation of dangerous trades. In Great Britain Sunday employment is forbidden.

The last decade of the nineteenth century and the commencement of the present have been marked by the appointment of several Departmental Committees of the Home Office. As I had the honour and the privilege of sitting as a member on a few of the Committees appointed to inquire into the effect of certain industries upon the health of the workpeople, to that circumstance and to the experience gained as a hospital physician must be attributed the *raison d'être* of this contribution to the subject of factory legislation and occupation diseases.

The work of the Factory Department of the Home Office has enormously increased within the last few years, and recent legislation tends still further to increase it. Beginning with four factory inspectors in 1833 there are now upwards

of 170 all told in the department. The appointment of special inspectors has been most useful. It is only within recent years that female inspectors have been employed, but the excellent work done by the Principal Lady Inspector of Factories and her staff of ladies has more than justified the creation of this particular section of the department.

Into the details of the Workmen's Compensation Act of 1906, which is an extension of the Act of 1897, I do not propose to enter. In this country industrial legislation is based upon experience and expediency, so that no sooner is an Act in operation than its weak points become apparent and a fresh Act is required to remedy defects and remove flaws, but it too generally ends in introducing controversial matter and in providing employment to lawyers and doctors. The Workmen's Compensation Act of 1906 repeals the Acts of 1897 and 1900, and it extends the principle of compensation to all classes of persons engaged under contracts of service, including domestic servants and sailors. In addition, by including certain defined trades, it makes employers liable to pay compensation for diseases arising out of and in the course of employment. By a "workman" is meant "any person who has entered into a works under a contract of service or apprenticeship with an employer, whether by way of manual labour, clerical work, or otherwise, and whether the contract is expressed or implied, is oral or in writing." Certain persons are outside the Act, *e.g.*, policemen, persons in the naval and military services, profit-sharing fishermen, non-manual workers whose remuneration exceeds £250 a year, and others. The Act is comprehensive and includes most trades and lowly-paid members of professions, among which are mentioned house-surgeons and hospital nurses. It also includes certain industrial diseases, the consequences of which may be immediate or remote and which are often more severe than accidents. A workman is entitled to compensation if he is incapacitated by a disease contracted in his trade and due to his employment exactly in the same way as if he had been thrown *hors de combat* by an accident. The following have been scheduled: Poisoning by nitro- and amido-derivatives of benzene or its sequelæ, carbon bisulphide

or its sequelæ, nitrous fumes or sequelæ, nickel carbonyl or sequelæ, arsenic poisoning or sequelæ, lead poisoning, African boxwood or sequelæ, chrome ulceration or sequelæ, ulcerations produced by dust or caustic or corrosive liquids, cancer or ulceration of skin or of corneal surface of eye due to pitch, tar, or tarry compounds, chimney sweeps' cancer, nystagmus, glanders, compressed-air illness or its sequelæ, beat hand (subcutaneous cellulitis) of coalminers, miners' beat knee and beat elbow, and inflammation of the synovial lining of the wrist-joint and tendon-sheaths of miners. In order to claim compensation a workman must produce (1) a certificate from the local certifying factory surgeon, (2) or prove that he had been suspended from his usual employment on account of having contracted one of the diseases scheduled, and (3) in the event of death proof will have to be given by friends or dependants that death was due to one of the diseases mentioned above.

It is generally conceded that the effect of the factory laws has been to improve the condition of labour in factories, to promote the health of operatives, to reduce the hours of labour, and to give the workpeople often healthier and more sanitary surroundings than they have at home. Much yet requires to be done, for factory life is not always so satisfactory as at first sight it appears. It is said that factories existed in Greece, Rome, and in the older civilisations, but these establishments were not factories in the sense we know them. The men, women, and children who worked therein were slaves, and their work was carried on under the eye of task-masters. The factory system of Great Britain was the necessary consequence of the introduction of machinery and the massing together of large numbers of workpeople in mills and factories. The first factory of modern type was built by Sir Thomas Lombe, in 1719, in Derbyshire, for the manufacture of silk. Other establishments soon followed, but many of them were of rude description, and in these the employés worked long hours, little regard being paid by the masters to the health of the workpeople. It was the age of *laissez faire*. There was no limitation as to hours of labour, the age of workers was not defined, there was little consideration

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shown to female workers, and no regard for health generally. Factory legislation has altered all these, and while the trend of industrial methods is in the direction of increasing the speed of machinery, and therefore of taxing still further the nervous energy of the workpeople, there is greater respect for the health of the workers and for their comfort than fifty years ago. The factory system has its defects. It is urged against modern industrial methods that they allow female labour and that as consequences of the increasing employment of women there are ensuing a weakening of home interests and a neglect of home duties. Where both parents work in factories, as in the cotton mills in Lancashire, there is little home life. The young children are taken from their warm bed in the early morning and carried by the mothers to a caretaker, usually an elderly female, with whom several children are left for the day. At the end of the day's work the mother calls on her way from the factory for her infant and proceeds to her home, all dark, cold, and cheerless, for the shutters have not been opened, the fire has not been lit, and no evening meal awaits them. Of home life for textile workers where both parents go to the factory there is almost none. All is made subservient to the requirements of the factory, whose incessant demands sap all that is best of family life and maternal instinct.

While there is doubtless much to condemn in the factory system there is also something to be said in its favour. Under the heading "Factory" in the American supplement of the "Encyclopædia Britannica," Mr. Carroll D. Wright, formerly Chief of the Bureau of Labour Statistics in Massachusetts, says that while by no means perfect, the factory system is in advance of previous methods of production. "The evils which were apparent during the early days of the factory system were simply the result of bringing together the labour which had become pauperised under the domestic system and in agricultural districts. . . . The factory has not so much destroyed the home as it has enabled members of broken families to earn a livelihood. If it has at times taken the mother from the care of her young children—the worst feature of the employment of married

women—it has enabled more who had no home to be self-supporting." It is claimed for the factory system that rather than tending to degrade, mentally or physically, those brought under its influence, it has raised the lower classes and improved their scale of living. Because better machinery has enabled less educated persons to engage in and accomplish what formerly required skilled labour, this fact does not necessarily imply that the work has degraded skilled labour, for it may have lifted the unskilled. Things were undoubtedly bad when the factory system was instituted. While it displaced many evils, several have been retained, some of which are only gradually being eliminated. Many of the present defects in our factory life and methods are therefore to be considered as less the result of the system than the outcome of want of knowledge on the part of the workpeople and of an unwillingness on the part of employers to recognise the fact that capital has duties as well as rights.

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DISEASES OF OCCUPATION

CHAPTER I

FACTORS CONTRIBUTING TO INDUSTRIAL DISEASES AND ACCIDENTS

NO matter what parliamentary legislation may enact, industrial hygiene will never be secured until the workers themselves are educated in regard to the dangers incidental to particular trades and are willing to co-operate in making Home Office regulations effective. There must be a greater amount of mutual trust and a heartier co-operation of employers and employed. Only thus is it possible to remove the stigma that attaches to many occupations and the cause of their unhealthiness. No person should be employed in a dangerous trade until the risks have been explained to him by the employers and the means indicated whereby danger to health may be averted. Of the conditions met with in factories that contribute to industrial diseases mention may be made of imperfect ventilation, absence of means for the withdrawal of dust, imperfect supervision of the workers, and inadequacy of washing appliances. Want of cleanliness has long been recognised as an important contributing factor, especially when combined with poverty, deficient food and clothing, and improper housing. Sex is in some instances a predisposing circumstance, as, for example, in the greater liability of women to plumbism and to the rarer types of the malady than men. Age, too, is not without its influence, for experience has shown that young adults of both sexes are more predisposed to lead poisoning

than persons of maturer years. The bad effects of overcrowding and of sleeping in ill-ventilated rooms are seen in the readiness with which fatigue is induced and in the inability of workers thus imperfectly housed to keep pace with their healthier comrades and the increased speed at which machinery is run. It is largely owing to the influence of fatigue that, as the day proceeds, the workers, becoming tired in mind and body, become careless, and as a consequence the number of accidents increases with the hours of toil. As a result of general fatigue the exhausted and overheated workman on leaving the factory is less resistant to the weather, and readily catches cold. In a similar manner groups of over-worked muscles readily become paralysed, compared with other muscles that are not so constantly in action. Knowing this fact, house-painters, by educating themselves to use both hands, become less liable to "wrist drop." There are certain people, the victims of an inherited weakness of the nervous system, the subjects of neurasthenia, others again the subjects of anæmia or bloodlessness, who through sheer physical inability are unable to do an ordinary amount of work and who are more quickly laid aside by industrial disease than others. Where the work is hard, and heavy weights have to be lifted or carried, the effect of such strain may show itself in rupture of a blood-vessel, the formation of an aneurism, dilatation of the heart, rupture of muscle, strained tendon, or hernia. The habits of the workpeople, too, are not without an important bearing upon their freedom from or their liability to industrial diseases. There is nothing that induces to certain forms of industrial poisoning or is more likely to become a cause of accident to a workman than indulgence in alcohol. An intemperate man is only courting disaster when he continues to work, for example, in a white lead factory. Apart from the imperfect character of the workmanship, the excessive use of alcohol makes a man careless and heedless of danger; he runs risks he otherwise would not incur, and to this circumstance may be traced many of the accidents that happen in docks and wharves, and to it, also, probably some of the shipwrecks that have taken place shortly after vessels have put to sea. The excessive use

of alcohol is a cause of epileptic attacks in men previously free from fits, and as epilepsy assumes many forms—for example, often only a sense of giddiness or faintness—it is not improbable that some of the unexplained falls of men which result in serious injury to life and limb, may be the result of ill-nourished, poisoned conditions of the nervous system, not the outcome of an immediate debauch but of long-continued indulgence in alcohol. If we add to alcohol the infection of syphilis we have in these a combination of circumstances the influence of which, from a medico-legal point of view, is far reaching so far as workmen's compensation is concerned.

It is an interesting problem to consider the probable effects upon the health of the workpeople in the future of the increased speed at which machinery is being run in the factories and the speeding-up of the work in shipyards. That there is greater strain upon the nervous system, more exhaustion and consequently need for greater leisure, few will deny, and that in many instances the hard work induces premature old age goes without saying. Will this speeding-up tend to make female mill-workers better mothers and help them to give birth to healthy and robust children, or to infants who are puny, ill-nourished and of a highly strung nervous system? In some American factories in which stitched muslin underwear is made, so great has been the improvement in the machinery of late that the sewing machines are carrying two to ten needles instead of one as formerly, and as a consequence many of the girls are no longer capable of the sustained effort necessary to follow the improved speed, and have been obliged to relinquish their occupation. The strain of the eyes in watching for broken threads, in order to stop the machinery, is almost intolerable; it requires an amount of nervous energy and a constancy of attention which the operators cannot supply. There is a limit beyond which the speeding of machinery cannot be run without detriment to the health of the operators unless their hours of work are materially shortened.

(Look up)

Clearly, therefore, there are occupations, especially the textile trades, that tend through sheer strain to wear out

the body of the worker and induce premature old age. These industries may be said to show their baneful effects upon the nervous system. In some of the so-called dangerous trades there is observed a vulnerability of certain organs of the body. Industrial poisoning, *e.g.*, plumbism, is prevented or retarded by the functional activity of such of the eliminating organs as the liver, intestines, and kidneys. Lead is thrown out of the system by the intestinal canal and kidneys. The predilection of lead for the liver is largely due to the fact that most of the lead which enters the body does so by the alimentary canal, whence it is absorbed and carried by the blood to the liver. It is abstracted from the blood by this organ and either thrown out in the bile or retained in the hepatic cells. Although lead has a strong affinity for nervous tissue and induces paralysis of the hands, arsenic rapidly causes an acute and painful neuritis which, like that due to alcohol, is principally met with in the legs and feet. It is the same with many micro-organisms. In the human body each poison has its special site of selection and its channel of elimination. It may be said of the tubercle bacillus, taking this micro-organism to illustrate my point, that notwithstanding the channel by which it has gained an entrance into the body, through the air we breathe, the food or drink we take, the tubercle bacillus ultimately finds its way to the lungs. There is a selection for certain organs or tissues of the body by poisons and micro-organisms that we cannot always explain.

Fatigue. General Aspects of the Question

Hurry and absence of repose are characteristic of our age. Life as a consequence is fuller. We put more into it than did our forefathers, but it remains to be seen whether in thus spending more we are getting a corresponding return. Among all classes there is both a demand and a need for a larger number of holidays than formerly. The pace at which we live, and the rate at which the industrial machine is run, create a wear and tear far in excess of

anything hitherto known. The pressure pervades all forms of human activity. Its effects are seen in the infant whose mother has no time to nurse her child, since she must be in the factory; it is felt by the pupil at school, the apprentice, and by the adult well-nigh on till the working day of life is done. In many occupations men are old at 55, and the years of declining life, which ought to be marked by quietude and repose, are frequently shortened, since relatives have no time to give the personal attention to the old that is necessary. Although the introduction of machinery has cheapened products and placed more of them within the reach of the poorer working classes, it has not always lightened labour. The rate at which machinery is run demands greater attention from the workpeople and imposes upon them a severe strain. To the artisan classes the Saturday half-holiday and the shortened working day have proved a boon from a purely physical point of view. Great as the rush and pressure are in this country, they are even greater in America. An attempt is being made to Americanise some of our industries. In the shipbuilding yards on the Tyne and elsewhere, so hard do the men in some departments work that it is impossible for the apprentices to keep pace with them. Not only is this "rushing" a cause of serious accidents, as a consequence of the hard nature of the work and the vigour with which it is sustained, but the men themselves are frequently so tired that many of them spend part of the Saturday afternoon in bed. When to fatigue is added severe strain the effects may be lamentable, as, for example, in the use of mechanical drills for ship-plates. The implement is very heavy, and has frequently to be held by a workman standing in an awkward position. I have been consulted by young workmen suffering from cardiac distress, owing to acute dilatation of the heart, consequent upon the use of mechanical drills. In the textile trades the speeding-up of machinery is responsible to a large extent for the tiredness and poor physique of the female workers. Where husband and wife both work in the factory the house is closed during factory hours and the children are confided to the care of a neighbour for a few pence per

day. Tired after the day's work, and the home unattractive, recreation is too frequently, but not always wisely, sought in music-halls and cheap theatres where, in a vitiated and overheated atmosphere, the opportunity is not given for the elimination from the body of the fatigue products formed during the day.

I have spoken of fatigue products, but what is fatigue? Fatigue or tiredness is a sensation, the outcome of a particular state of the nervous system, the result of work carried beyond the capabilities of the organism. In ordinary physiological activity exhaustion is never attained, for fatigue is the warning signal. In each of us there is a certain amount of reserve force which allows our muscles and nerves to be overtaxed at times without injurious consequences. The increased functional activity is met by a corresponding improved nutrition, whereby recovery is secured. Life involves change of structure. The waste products added to the blood act upon the nerve endings in muscle and upon the grey matter of the brain, and create a sense of fatigue. Although the sensation of tiredness is referred by us to the overworked muscles, the location of the cause is less in the peripheral than in the central nervous system. On the one hand waste products act upon the muscles, diminish their contractility and render them less responsive to nerve stimuli; and on the other hand they poison the large nerve cells in the grey matter of the brain, render them less receptive of sensory stimuli, and in this way reduce their power of emitting volitional impulses. There is, therefore, in fatigue an element that is mental as well as physical. After rest and sleep the sensation of fatigue wears off, we rise invigorated and strengthened for work. During repose structure is being rebuilt and waste products are eliminated. The proof that the circulation of waste products in the blood is a cause of fatigue is demonstrated by taking some of the blood of a fatigued animal and injecting it into a healthy one, when in the latter the physical signs of fatigue gradually appear. Weichart, in 1904, advanced the theory that the cause of fatigue is a toxin generated in the overtaxed organism, and that the ravages of the toxin, like the poison of

diphtheria, can be met by the introduction of an antitoxin into the body. Wolf-Eissner (*Centralb. f. Bakteriol.* bd. xl., 1906, p. 634) is of the opinion that, during athletic training there is produced an immunity to the toxin of fatigue, whereby the trained athlete becomes capable of accomplishing more than the untrained man, and without experiencing the sensation of fatigue. It is common knowledge that men who are doing hard, physical toil regularly have not the sense of tiredness felt by men who are new to the work, and we explain this by saying that the latter are not trained. Wolf-Eissner throws new light upon the subject. Having obtained a fatigue toxin from overworked animals, he injected small doses of the poison into other animals and produced in them symptoms of fatigue, drowsiness, and a lessening of activity. Large doses caused death, but if very minute doses were injected for a lengthened period there was established in the animals a genuine immunity to fatigue. The toxin is not found in the blood but in the muscles, whereas the antitoxin is only present in the blood. There are certain people whom I have already alluded to as neurasthenic who are languid physically and mentally, and who are so readily tired that they are unable to take up the ordinary duties of life. We speak of them as being deficient in nerve force, but may the explanation not be that their condition is one of toxæmia and that they are unable to produce the antitoxin of fatigue?

Men and women who have worked hard and been exposed to the weather often look older than they are, and they give evidence of arterio-sclerosis or structural changes in their blood-vessels. A man's age is largely that of his heart and arteries. In men who have wrought hard the circulation of waste products in the blood comes in time to tell upon the kidneys, heart, and blood-vessels. The human body, as already indicated, is not without its defences against fatigue, and the evil effects upon the heart and kidneys consequent upon the long-continued retention of waste products in the blood. A. Mossaglia (*Gazett. deg. Ospedale e Delle Cliniche*, an xxvii., 1906, 2 Sept., No. 105, p. 1103) has shown that in dogs from whom portions of the parathyroid glands have

been removed, the production of fatigue is always followed by tetanic convulsions and the presence of large quantities of albumen in the urine, a circumstance which points to the secretion of the parathyroid glands possessing a specific body which neutralises the toxins formed during muscular work. In the case of several young soldiers after a march out, Sir Thomas Grainger Stewart found a trace of albumen in the urine, but in healthy subjects muscular exercise is not followed by the presence of albumen in the urine, or if so, never to any extent. The presence of albuminuria after physical exercise in dogs whose parathyroids have been partially removed indicates that there is a functional relation between these glands and the kidneys. The toxins of fatigue are capable in course of time of contributing to kidney diseases, and in man the thyroid gland when healthy obviates this to some extent through the internal secretion which it forms.

As the result of overwork Hodge, an American physiologist, found structural changes in the nerve cells which rest removed. F. H. Scott (*Journ. Physiology*, vol. xxxiv. Nos. 1 and 2, p. 145) states that in nerve cells there is formed from the nucleus and Nissl bodies of the cell a substance which passes into the nerve fibres. These fibres are capable of carrying impulses without becoming fatigued, but they cannot maintain the end-organs of the nerve in a condition of activity beyond a limited period. It would appear, therefore, as if some substance were given out from the nerve cells, hence as a consequence the readier fatigue of the central nervous system compared with the peripheral. Scott tried to locate the seat of fatigue. Muscle fibre may become fatigued, also the nerve cells in the spinal cord, owing to the hypothetical substance already alluded to being used up and time not given for fresh secretion to have been formed.

The effects of fatigue, mental and physical, are shown on various organs and functions. Intense intellectual effort maintained even for a short period increases the beat of the heart by 5 to 20 in the minute with a fall to the normal, or even below it, on cessation of work. Mental work, when not

too prolonged, gently raises the arterial pressure and the temperature, the muscles of the eyeballs become relaxed and the pupils dilated and the crystalline lens flattened—phenomena exactly the inverse of those observed during accommodation. When the duration of physical work is short the muscular force of the hand, as measured by the dynamometer, is increased, but if prolonged the work done by the muscle decreases. The amount of urine increases and there is a slight excess of phosphates. The changes brought about by muscular work were found by Byesson to be the opposite of those caused by intellectual work. G. Binet showed that in scholastic institutions the amount of bread consumed fell with the increased amount of mental work of the scholars, and that the body lost weight. One of the important features of overwork calling for notice is the manner in which fatigue is repaired. It is a question of length of time; some persons require a longer time than others to recuperate. It is easier to study muscular fatigue than mental. During inactivity living muscle is absorbing oxygen from the blood and is throwing off small quantities of carbonic acid—it is storing up glycogen and fat; but during activity the nutrition of the muscle is quite altered. A larger quantity of oxygen is absorbed, the carbonic acid evolved is considerable, glycogen disappears, for it is used up, and the temperature rises. The contractile substance of the muscular fibre becomes acid in reaction, owing to the presence of lactic acid and other derivatives. Whenever muscular activity is carried to the point of exhaustion, glycogen, which is the source of the muscular energy, disappears. It is used up, being transformed into carbon dioxide and water with lactic acid. Although deprived of glycogen, muscle can still contract owing to the nitrogenous substances it contains. Muscular activity requires nervous activity as well. Nerve cells as producers of force, nerve fibres as carriers, and muscles as the agents of contraction are all involved in manual labour. Each of these plays its own part in fatigue. The waste materials formed not only induce a sense of fatigue, they exercise a paralysing influence upon the nerve endings in muscle. In animals that died from fatigue H. M. Bernard

found a mottled condition of the muscles, alteration of the nuclei, and under the sarcolemma fine droplets, which were apparently dissolution products of myosine. Similarly structural changes are met with in the nerve cells in the grey matter of the motor areas of the brain. These changes include chromatolysis, irregularity of the outline of the nuclei of the cells, and a displacement of the nuclei. It would seem that in fatigue there are three factors in operation. (1) Accumulation of waste products; (2) using up of the energising substance, muscular and nervous; and (3) structural changes in muscle fibre and nerve cell. The using up of the energising substance, even to the point of exhaustion, is a normal or physiological process, but the poisoning by disassimilation products is more or less pathological, since it may be followed by definite alterations of cell structure. Physiological fatigue is gradually recovered from by rest.

When the muscular work is hard and there is considerable strain as well, there is a rise of blood pressure which is not without some influence upon the heart. The heart in its beat has to overcome resistance; if it cannot do this readily the organ dilates. Acute dilatation of the heart is one of the early physical signs of fatigue, and yet it can be prevented to some extent by gradual training. In a man who, by degrees, is trained to hard muscular work, the heart, instead of dilating, hypertrophies; it becomes larger and stronger and therefore more fit for the requirements of the circulation. Hence the heaving cardiac impulse of the labourer's heart and the accentuated second sound heard over the aortic area. So long as these men are doing hard work we cannot regard the condition of their heart as pathological. What sends the labourer wrong is not so much the fact of his having a hypertrophied heart or of his doing hard work, as alcoholic indulgence and irregular habits superadded to muscular strain. In a large percentage of the working men who come under my care in the Royal Victoria Infirmary, Newcastle, suffering from heart disease, who are broken down in health, the history is generally one of exposure to weather, muscular strain, alcohol and

syphilis. In forgemen who are wielding a heavy hammer it is easy to understand that with respiration suspended and the chest kept fixed as in expiration, the thoracic and abdominal aorta is compressed and the right heart and venous system distended with blood.

Physical effort and the lifting and carrying of heavy weights not only impress themselves upon the muscles and nervous system, but upon all parts of the body, particularly the bones in early adolescence and the period of growth. Hence the stunted growth of the clay-carrying children engaged in brickfields, and the deformities of the body and spinal curvature met with in persons as the result of standing the greater part of the day in a strained position when at work. If standing all day when at work in an over-heated factory causes tiredness of the muscles and also varicose veins, prolonged sitting may be just as harmful, for the lumbar region of the spinal column becomes bent, the movements of the abdominal viscera are interfered with, the lower ribs are compressed, and since deep inspiration is hardly possible the lungs are badly ventilated and the aeration of the blood is imperfect.

To protect against excessive fatigue we should encourage regular and temperate habits on the part of the workpeople, personal cleanliness, the use of good food, sleeping in well-ventilated rooms, and the avoidance of over-crowding as far as possible. It is difficult, if not impossible, for the poorer working classes, living as they often do in the slums of large towns, to observe and obtain these. If we cannot control the hygienic conditions of the homes of the working classes, we can at any rate insist that in the factory and workshop the conditions under which work is carried on shall be as healthy as possible, that means shall be in use to carry away dust, that the temperature and humidity shall not be too high, and that the air shall contain even less carbon dioxide than is allowed by law. If employers wish to have tidy and clean workmen they must keep their factory clean. Change of clothing after working has a refreshing effect upon most people, and workmen who have washed in the factory and changed their clothing will probably make a better meal on reaching home than the

unwashed workman. The hours of toil should be proportional to the nature of the work and its fatiguing character. Upon young persons the burden of work should be lightly imposed, and the individual gradually trained to it. Fatigue in the case of pregnant women should be avoided by not allowing them to undertake work of an arduous nature, and by forbidding them going on with their work until the end of term.[1]

Traumatism, Tuberculosis, and Cancer. Medical Aspects of the Question

Since in the wake of an injury there frequently follows local or general disease, the question necessarily arises whether these stand related to each other as cause and effect. A short while ago there came under my care a young woman who, when crossing one of the streets in Newcastle, was knocked down by a passing vehicle. Until the day of the accident she was a healthy woman and was not known to have been ill. Her chest was bruised but no ribs were broken. Shortly after the accident she began to spit blood. From time to time she had recurrent hæmoptysis. Physical signs of pulmonary consumption rapidly developed, and within a year the patient died with all the symptoms of tuberculosis ot the lungs. The diagnosis was confirmed by post mortem examination of the body. I was much impressed by the circumstances of the case, and could not altogether eliminate from my mind the *post hoc propter hoc* theory that the lung disease was the result of the accident. Since then I have seen other cases of injury to the chest wall followed for years afterwards by recurrent hæmoptysis: thus the question of the

[1] After a discussion on fatigue at the International Congress of Hygiene at Berlin, September, 1907, the following resolution was passed: Since the capability for work varies not only individually according to the constitution, age, sex, and mode of life, but also in the same individual at different periods of life, a permanent skilled control must be kept in all manual or intellectual industries, including business occupations, and also occupations in which workmen are exposed to special dangers; this should be carried out in such a way that a proper allowance would be made for the individual capability for work.

possibility of a causal connection between injury and tuberculous lung disease is one to which an answer must be returned, and especially so in view of the Workmen's Compensation Act.

The sequence of trauma and tuberculosis has hitherto not attracted much attention in this country, either because of the infrequency of the occurrence, or because medical men with their knowledge of the bacillary cause of tubercle have not thought it necessary to inquire into the possibility of such a relationship. On the Continent, where compensation for injuries received at work has been carried further in some respects than in Britain, the subject has been frequently forced upon medical men for their opinion, and what has occurred in European countries will shortly take place in our own. Medical men will be obliged to have an answer ready to the question, Can an injury be the determining cause of tuberculosis, or is it that injury simply lights up a tuberculous lesion until then latent and possibly on its way to spontaneous cure? If an accident received at work is the cause of tuberculous disease of a subjacent organ, which disease but for the accident would not have arisen, the claims for compensation advanced by the injured person, or his relatives, are not without a reasonable foundation. The difficulty will always be that in most of the cases there is no proof of the healthy condition of the body previous to the accident, a difficulty not lessened but rather increased by the fact that in about 70 per cent. of the bodies of persons dying from all causes there are evidences of healed localised tuberculosis of the lungs. At the Morgue in Paris Professor Brouardel found old tuberculous lesions in one half of the bodies of persons above 30 years of age; and Letulle, at the Hôpital St. Antoine, Paris, in 131 autopsies in cases of violent death, found evidence of pulmonary phthisis in 25. We all know how tuberculous gland disease can exist for years without giving rise to symptoms. The disease remains latent until, perchance, the glands become inflamed or they soften and rupture and allow the imprisoned tubercle bacilli to escape. A man or woman receives a blow on the chest, has a hæmorrhage or not, as the case may be, and he dies months

afterwards from pulmonary phthisis; or he meets with an accident when at work, the injury is regarded and treated as a sprain, but it is followed by a "white swelling" of the joint, which is tuberculous. What is the association? Medical opinion is divided. There are many surgeons who believe that tuberculous disease of the joints and bones may be the consequence of an injury, but when we consider how many shocks and blows persons, young and old, are receiving and how infrequently in comparison "white swelling" of the joints appears afterwards, the association of trauma and tuberculosis cannot be so very close and frequent, otherwise we would have seen and heard more of it than we have. It is an interesting fact that in these cases where patients have given a history of injury there has been in nearly every instance no fracture of the subjacent bone and no tearing, but only bruising, of the skin, yet of 159 individuals who received penetrating wounds of the chest-wall Demme found that 17 died some time afterwards from pulmonary phthisis. One of the first to draw the attention of the profession to this subject was Professor Teissier, of Lyons (*Lyons Médicale*, 1873, p. 10). A male patient, a baker, aged 30, who had never had an illness, and who was in perfect health at the time, received a blow on his right chest and shoulder by a falling beam. So violent was the blow that the patient was rendered unconscious. None of the ribs were broken nor was the shoulder-joint dislocated, but there was swelling with redness of the right shoulder-joint. Immediately after the accident the man brought up a large quantity of blood by the mouth, and for eighteen months afterwards hæmoptysis was frequent. Three years after the accident Professor Teissier, finding the man in advanced phthisis, concluded that the pulmonary consumption was the result of the accident and hæmorrhage. About the same date a shoemaker, believed to be in perfect health, was struck in the chest by the pole of a carriage. This man had immediately afterwards a severe hæmoptysis, which continued off and on for several days and then remitted, but the patient succumbed later on to phthisis. Teissier published his cases before the discovery of the tubercle bacillus by Koch. He was of the opinion that an

injury was capable of causing, through the blood that escapes, a bronchial irritation which ultimately leads to pulmonary phthisis in persons predisposed to the malady. It was therefore a *phthisis ab hæmoptæ*. In 1875 Perroud drew attention to the frequency of phthisis among the sailors on the Rhone. These men are of good physique and they follow a healthy occupation in the open air. The disease was attributed to the men leaning with their chest wall upon the pole of the rudder in steering their ships. It was thought that the repeated pressure favoured the development of pulmonary lesions, the interesting point being that the maximum focus of the disease as revealed by auscultation always appeared to be located at the level of the point of pressure by the pole, viz., under the right clavicle. The sailors themselves were of the opinion that their illness was the result of leaning on the pole.

In 1884 Germany decided to compensate workmen for accidents received at work. At first it was principally "white joints" coming on after injury that furnished the objects for consideration. Honsell (*Beatr. Klin. Chir.*, 1900, tome xxviii. p. 659) investigated 1,729 cases of so-called articular rheumatism. He found in 242, or 14 per cent., a traumatic origin. In 577 cases of tuberculous disease of bones and joints under the care of Rostock between 1890–1902 Voss obtained a history of traumatism in 125: 88 per cent. of the patients were between 30 and 40 years of age, and 4 per cent. between 50 and 60. In nearly every instance the accident was a luxation or contusion, in only one instance was there a fracture. Voss concluded that in one-third of the cases the lesion was not of traumatic origin, in one-third the influence of traumatism was doubtful, while in one-third injury had played a part. When a white swelling of a joint has developed a patient naturally tries to account for it, and he is tempted to recall to memory some injury, severe or slight, to explain the occurrence of his malady.

There have been, comparatively speaking, few literary contributions to the subject of traumatism and tuberculosis in British medical periodicals. One of the most interesting is from the pen of Dr. James Weir, of Glasgow (*Brit. Med.*

Journal, May 23, 1903, p. 1196). He reports the case of a man not altogether free from a tuberculous family history who had had pneumonia in the left lung more than twenty years previously, and who received a severe blow over the lower part of the right chest and mid-axiliary region when at work. He was treated at the time for a bruised side. Two weeks afterwards he was found to be suffering from what appeared to be pleurisy. Two months later there were cough with expectoration, hæmoptysis, signs of consolidation at the right apex, and considerable emaciation. The sputum on being examined was found to contain tubercle bacilli. Under treatment by creasote, cod-liver oil, &c., patient improved considerably in strength and weight, he lost his cough, tubercle bacilli disappeared from the expectoration, and the right apex became clear and free from râles. In Dr. Weir's patient the part of the lung that became affected corresponded with the injury to the chest wall, and as the man had been apparently quite well at the time of the injury, an opinion was expressed in favour of some connection between the two events. The effects of the bruising had penetrated the wall of the chest, had reached the pleura, and after affecting it had either set up pathological changes in the substance of the lung itself or weakened it functionally. A focus of tubercle in the lung substance just underneath the pleura is apt to set up a limited patch of dry pleurisy; but may not pleurisy as a primary lesion, such as that caused by an injury, so impair the function of the underlying lung as to render it a suitable nidus for the development of tubercle bacilli? Experience shows that it is in those portions of the lungs that move least in respiration and are therefore the least well ventilated, viz., the apices, that tubercle bacilli are most prone to develop. The effect of pleurisy upon subjacent lung is to impair its movements; the lung neither expands nor contracts so well, morbid secretions are retained in the small bronchi, stagnation occurs, and the vitality of the lung tissue is reduced. These are clinical facts, but an appeal may be made to experiment. Von Krause, in 1890, inoculated guinea-pigs under the skin, and rabbits in the pleura and peritoneum, with pure cultures of Koch's

bacillus. He subsequently caused contusion and sprains of their joints, and in a few instances fracture of the bones and dislocation of the joints. Three to seven weeks after the injuries several of the animals died from miliary tuberculosis. Some of the animals that had received bruises presented the lesions of joint tuberculosis, viz., 34 per cent. of the guinea-pigs and 50 per cent. of the rabbits. There were also evidences of tuberculous disease of the lungs. In other experiments, carried out by Lannelongue and Achard although the animals died from tuberculosis, there were no tuberculous lesions in the lungs, but in their experiments the injuries were not inflicted until nineteen to twenty-one days after the inoculation, too late to determine the relation of tubercle and injury. Petrow (*Central. Bl. f. Chir.*, November 26, 1904) injected tubercle bacilli into the peritoneal cavity of twenty-six guinea-pigs. All of them died of tuberculosis. In fourteen of them there were, on histological examination of the epiphyses of the joints, evidences of tubercle, and yet during life there had been no signs present to betray its existence. In other words, a latent tuberculous arthritis had been established. In another set of experiments Petrow injected tubercle bacilli into healthy joints, and also into other joints previously subjected to traumatism. On a subsequent examination of the joints of animals that had not been previously injured, the tuberculous lesions remained limited to the ligaments and the capsules round the joints, but in the traumatic joints the lesion invaded the cartilages and the bones. These experiments show how aggravated become the symptoms and how extensive the tuberculous lesions when the joint has been injured as well. Whatever our views individually may be upon this subject, we cannot but admit that injuries play an important part in lighting up pre-existing microbic affections. Tuberculous lesions of lungs and joints may be latent and for a time unattended by symptoms until an injury, perhaps, is received, when a tuberculous lesion that was dormant becomes active.

It is a question whether the subject under discussion can be settled by experiment alone, since in animals tubercle bacilli are usually injected in larger quantity than occurs in man.

In them the blood is flooded with the micro-organism, but in man the invasion is slow, and the injuries are not always comparable with those experimentally produced in animals. In the development of tuberculosis after an injury there are two points to be borne in mind: (1) at the time of the accident Koch's bacillus may have been already present in the body of the injured person, either in the part struck or at some distance from it; and (2) the injury received increases in some way or other the virulence of the bacilli. The rôle played by injury may be simply that of an accessory. Had the accident not occurred at the particular time, tuberculosis might probably have developed all the same, but from the Workmen's Compensation point of view, since the injury roused into activity what ultimately became a fatal disease, a claim for partial compensation under these circumstances is not altogether unreasonable.

Dr. Mosny, of L'Hôpital St. Antoine, Paris, is of the opinion that an accident determines in a general way the development of a localised tuberculosis at the point struck, only when the malady already existed there in a latent form. It requires, according to him, a local congestion of the blood vessels to light up the malady, hence an injury, by creating an inflammatory condition, is thus able to light up disease till then latent. A contusion acts in a similar manner. It is not necessary to have the skin broken in order that deeper seated tuberculosis shall thereafter develop. An injury may unmask a latent tuberculosis, or it may aggravate an existing tuberculosis in a patient who is already phthisical and hurry on the disease to a fatal termination. Taking this view of the matter the injury would only reveal a morbid state which was there before, but was not causing symptoms, so that when a person receives an injury to his chest and shortly afterwards has a spitting of blood, the hæmoptysis would be simply a sign of tuberculous lesion of the lung already in existence, the vascular equilibrium of which had become broken by the injury. But there are several cases of recurrent hæmoptysis after injury that have come under my own observation, where I am convinced the lungs were healthy before the accident, for since the injury, beyond a

recurrent hæmoptysis once a year or once in two years, the most careful examination of the lungs has failed to reveal the existence of tuberculous disease of the lungs. But this is in people whose family history and whose previous health were good. What might have happened in persons predisposed to phthisis it is impossible to say. In all probability tuberculosis would have supervened. An injury to the chest wall is sometimes followed by a limited inflammation of the lung of an indefinite type, which is slow to disappear. A lesion thus created becomes a fit soil for the reception and multiplication of micro-organisms of various kinds, including the tubercle bacillus. It is convenient in these cases to fall back upon a pre-existing localised tuberculosis, but this is only assumed, for there is no proof of such before the injury. Sudden and profuse hæmoptysis coming on shortly after an accident cannot in every instance be due to an already-existing tuberculosis of the lungs. The vascular conditions upon which the bleeding depends may be, therefore, a direct consequence of the injury through the intermediation of the nervous system, so that if the tubercle bacillus which lives, as some pathologists maintain, as a saprophyte in the upper respiratory passages is not kept in check by the phagocytes of the lungs and bronchial mucous membrane, the tubercle bacillus might become grafted on to the pulmonary lesion, a circumstance likely to occur if the patient at the time is run down in health and is living under unhealthy or depressing conditions. The injury would prepare the way for infection by tubercle. Dr. Marix, of the Prussian army, gives the statistics of 79 cases of soldiers injured in the chest. In 21 of them there subsequently developed tuberculosis. The micro-organism was found in the expectoration of 7 of the patients 3 months after the accident, in 8 of the soldiers from 3 to 11 months after, in 5 after 12 months, and in 1 after 7 months. In 2 of these 21 soldiers there was a family history of phthisis. Seven of the soldiers were received into the hospital immediately after the injury. There is no definite date at which tuberculosis develops after an accident to the chest wall. Tubercle bacilli have been found in the sputum as early as one month after an injury.

A subject such as we have been discussing would be incomplete did we not take into consideration the relationship of profuse "blood spitting" after severe muscular strain, without external injury and pulmonary phthisis. One illustration of several will suffice. I have recently seen, in consultation with Dr. Dinsmore, of Backworth, a colliery engine winder, aged forty-seven, suffering from recurrent bleedings from the lungs, attended by the physical signs of consumption. Twelve years ago, when a typically healthy man and free from any family tendency to tuberculosis, he lifted a heavy iron manhole door. He was conscious that he had overstrained himself, but he paid little attention to the feeling of faintness and sickness at the time. On the following forenoon when at work he was suddenly seized with profuse bleeding from the lung. He went home, stayed in bed, and in a week or ten days was well again. For five years he kept, on the whole, well, when he had another spitting of blood. Since then he has had recurrent bleedings every few months or weeks, which have so enfeebled him that he can no longer follow his employment. In the chest there are the physical signs of phthisis. The phthisis in this patient is as much the consequence of the traumatic hæmoptysis as if, instead of coming on years after the accident or strain, it had developed immediately afterwards. The fact that the blood spitting did not show itself until the day after the strain does not militate against the relationship between the two. My experience of this in other patients is that the hæmorrhage usually occurs on the second day after the strain and not immediately after it.

It is the circumstance of the small number of cases of tuberculosis following accidents, not more than 5 per 1,000, that diminishes the value of the relationship. A closer intimacy, on the whole, exists between injury and tuberculous disease of the joints and bones, than between injury and disease of the lungs. While some surgeons give the percentages as varying from 8 to 40, the average is 12 to 14. This is higher than our experience in Newcastle. The medico-legal aspect of this question cannot be ignored. Some of my readers will be called upon to express an opinion when a claim has been raised as to whether (1) the

accident lit up a tuberculosis that was latent or was possibly on the road to cure; (2) accelerated a tuberculosis that was in process of evolution; or (3) prepared the tissues for the reception of the tubercle bacillus. If it can be shown that but for the accident a man would have remained in good health and been able to follow his employment the claim for compensation will have to be carefully considered. This will necessitate an inquiry into the personal and family history of the injured workman and medical affirmation as to the absence of previous pulmonary disease. It is extremely desirable, too, that a stethoscopic examination of the patient's chest should be made soon after the accident, and such conditions noted, for example, as the location of physical signs in the lung compared with the site of injury to the chest wall, not that the disease invariably develops at the same spot. In Germany the question of compensation does not arise in this manner, for sick workmen are paid out of sick, accident, or old age funds that are managed by the State. In Great Britain the trend of legislation is in the German direction.

As after an injury to the chest wall pneumonia has occasionally supervened, the question is sure to be raised as to whether there is any causal connection between the two. Pneumonia is as much a microbic disease as is tuberculosis, but it is more definite both as regards its invasion and period of incubation. In several instances, varying from four hours to four days, pneumonia has developed after a contusion of the chest wall. In some patients the disease has not developed until the sixth day after the accident, and in one case not till the fifteenth, but even in these patients there were previously cough, sanguinolent sputa, and pains in the chest on deep inspiration, all suggesting that the disease had existed for several days before the patient had been seen by the doctor. Part of the pain complained of is probably the result of the injury to the side and not of the concurrent pleurisy as in ordinary cases. In dealing with this subject of the relation of traumatism to pneumonia, it must be borne in mind that a patient might go on working for a few hours after or just at the time a pneumonia was developing, or had only begun to

manifest itself, so that an injury received then could not be the cause of a malady that was clearly antecedent to or concurrent with a supposed injury. A patient may go about with an "ambulatory" pneumonia for a few days and die rather suddenly from it, when a lobe of the lung is found to be in a stage of red hepatization. All these facts have to be borne in mind when the subject of contusion pneumonia is under consideration. One prominent symptom is that in traumatic pneumonia there is generally a history of hæmoptysis shortly after the accident. The micro-organism of pneumonia is normally present in the mouth and buccal secretions of healthy persons. When, therefore, a man has met with an accident to his chest wall and hæmoptysis has occurred, the diplococcus which until then had been leading a saprophytic existence in the mouth probably finds in the sanguinolent expectoration and in the lung tissue altered by the hæmorrhage a medium favourable to its development. Probably my estimate is above the mark when I say that in not 1 per cent. of the cases of pneumonia is there a history of an accident, and yet I have known of cases where the one has followed the other. As far back as 1896 Professor Jacoud reported to the Academy of Medicine, Paris, the case of a man who had received a blow on the chest which was followed by hæmoptysis. A few days afterwards there supervened pneumonia, which was at the time regarded as the result of the injury. Five months afterwards tubercle bacilli were found in the sputum and a cavity was detected at the site of the previous pneumonia. As tubercle bacilli were absent during the pneumonia Jacoud was of the opinion that the localised pulmonary inflammation had, by reducing the vitality of the lung, paved the way for the entrance of the tubercle bacillus.

Contusion or traumatic pneumonia in no way differs, either as regards its clinical features or bacteriology, from ordinary croupous pneumonia, except that the expectoration contains more blood and there is a history of hæmoptysis. Although the physical signs of the pulmonary disease, *e.g.*, dulness on percussion, crepitant and other râles, usually appear at the site of the injury, this is not necessarily the case. Frequently

there is nothing to be detected externally on the side that was said to have been injured.

In cases where pneumonia and tuberculous diseases have appeared after accidents and the malady has led to a fatal termination, no opinion as to the relation of the accident and the disease should be expressed in a court of law without a post-mortem examination having been made. Acute pleurisy with effusion, for example, may develop any time from two to six weeks after an injury to the chest wall, and while in the fluid removed by aspiration from the chest for diagnostic purposes no micro-organisms may be found, yet on injecting some of the fluid into guinea-pigs tuberculosis may develop, and at the autopsy of the injured workman evidence may be found of old tuberculous disease in the apices of the lungs. The pleurisy in such a case would be tuberculous and due to pre-existing pulmonary disease. In a similar manner tuberculous meningitis in children and also in adults occasionally develops after an injury to the head, yet in nearly all the fatal cases there have been found at the autopsy either caseous glands or recent or old tuberculous lesions in the lungs.

Blows upon the abdomen and strains and injuries to the back seem, according to Rolleston ("Allbutt's System of Medicine," vol. iv. p. 542), to have been the cause of Addison's disease, either by the injury impairing the vital resistance of the suprarenal glands as to render them more vulnerable to the tubercle bacillus, or by giving rise to hæmorrhages in them. Since traumatism can cause inflammation of serous and synovial membranes such as those of the pleura and joints, there is no reason why it may not also cause peritonitis. Injury does not appear to be often, if at all, directly productive of appendicitis in previously healthy persons. The cause of appendicitis is more probably *ab intra*, but injury of the abdomen might readily reveal a latent appendicitis or give rise to a hæmorrhage into the appendix. Traumatism, shock, and exaggerated muscular effort are more likely to re-light an appendicitis that had died down and had become cured without operation. Where this occurs and an operation has to be performed, is the injury to be regarded as

the cause of the malady, and is the individual therefore to be compensated? There is little doubt that the extension of the Workmen's Compensation Act will tend to bring within the category of injury many illnesses that have hitherto been considered in no way directly associated with traumatism. The importance of this remark is at once apparent in such a case as the following. A man who is known to indulge too freely in alcohol receives an injury. The injury of itself is so slight that under ordinary healthy circumstances recovery would be rapid and complete, but owing to the man's habits delirium tremens develops, and in the course of this the patient dies. But for the accident there would have been no delirium tremens; to that extent, therefore, the injury has determined the malady, but had there been no excessive indulgence in alcohol there would have been no delirium tremens. What view will British lawyers take of such an association of circumstances? The French Act of 1898, recognising that traumatism had played even a small part in the development of symptoms, would indemnify the relatives.

The relation of malignant disease and injury is frequently raised in medico-legal inquiries. That cancerous and sarcomatous tumours develop after an accident, close to the site of the injury, and that the one is the direct sequence of the other, there is not the least doubt. How the tumour comes we do not always know. A man receives an injury to the right side of his chest and dies ten months afterwards from malignant disease of the liver; another man falls on his head in a shipyard, and a year or two afterwards dies from a sarcomatous growth in the brain. In some cases the connection is clear enough and the claim for compensation can be honestly maintained, but it is absolutely necessary, in all such cases leading to a fatal termination, that a post-mortem examination should be made in order to ascertain whether what is apparent on the surface of the body is the primary or secondary growth. Only recently my opinion was asked in the case of a man with a malignant growth in the glands of the right side of the neck, who stated that when carrying a plank two months previously he had slipped and had thus injured his neck. A medical man who saw him two or three

days after the accident certified that the patient had ruptured some of the muscular fibres above the clavicle, and, as a consequence, the employers paid him his wages. When I saw the patient, in addition to the large mass of glands in the neck, there was loud, stridulous breathing, which the glands in the neck, from their situation, could not explain, and on careful conversation with the wife of the injured man I learned that on the evening of the accident she had detected a nodular swelling in the neck. At the autopsy, two other medical men and myself found, as was expected, that the glandular mass above the clavicle was but an extension upwards of a much larger growth inside the chest which had encircled the trachea and was the primary seat of the disease. The necessity of a post-mortem examination in all cases where malignant disease is said to have followed an injury must be insisted upon. It is impossible to discuss at length all the diseases, especially those of the nervous system, that may develop after injuries. Diabetes insipidus may be a direct consequence of a fall upon the back of the head ; there are numerous forms of traumatic neuritis and a host of neuroses, all of which must be dealt with on their own merits. Nor can the subject of hernia and its relation to strain and injury be dealt with here. Common-sense and experience must guide a medical man in coming to an opinion upon these points. Rupture of the diaphragm followed by hernia of the stomach into the left pleural cavity is a serious condition occasionally met with in railway servants who have been crushed between the buffers of wagons, and in whom the diagnosis would be made by the displacement of the heart to the right, the presence of tympanitic resonance in the left chest, hæmoptysis and physical signs of hæmo-pneumothorax if the lung has been torn, coffee-ground vomiting and a diminution in the circumference of the abdomen. Pain is complained of over the precordium and in the dorso-lumbar region of the spine. Severe as the accident is, many of the injured apparently suffer very little at first, but serious symptoms soon show themselves. In an accident such as this, if the patient's condition permitted of it an X-ray photograph would be of considerable assistance

in making a diagnosis. It must always be borne in mind that a severe injury to the chest or abdomen may cause rupture not only of healthy organs, *e.g.*, spleen or kidney, but may induce rupture of a latent thoracic aneurism or a hydronephrosis, and thus lead to death. A fatal termination under these circumstances would be none the less the result of accident, notwithstanding the previous existence of serious disease.

There are certain trades in which cancer occurs with greater frequency than others. As the subject is dealt with in other parts of this book, allusion need only be made here to chimney-sweeps' cancer and the occurrence of malignant warts on the forearms of coal, grease, and paraffin workers. Dr. John Clay has recently drawn my attention to the presence of a malignant wart on the back of the hand of a bacon-curer. This is an unusual situation for a malignant wart. It is therefore probably more than a coincidence.

Simulation of Disease in view of Compensation

In countries wherein conscription imposes upon the able-bodied male population the burden of carrying arms, it is easy to understand that all kinds of deception will be tried in order to evade this national obligation, and in countries in which workmen receive compensation for injuries and diseases of occupation there is frequent resort to fraudulent methods to obtain money. In Germany and Switzerland, where compensation has been extended to workmen for several years, it is known that the workmen have taken full advantage of the Act, and that in many instances they are accused of having made convalescence as protracted as possible. It is only recently in France that the benefits have been extended to the working classes, but already in France there has grown up a special literature dealing with malingering.

Many of the monographs written upon the subject expose a state of things that does not bid for amity between employer and employed. There is, perhaps, too great a tendency on the part of the public to make a comparison

between an injured workman who is generally poor and an employer who is believed to be wealthy, and as a consequence the sympathy of the working classes and of a large section of the public goes with the injured workman. By this expression of sympathy and wide support the simulation of disease is rather fostered than otherwise. The problem of simulation has a double aspect. It is not only a question of a workman who has been injured pretending to be the subject of a disease from which he is quite free, it is also one of a workman, for example a lead worker, continuing to follow his employment and concealing his symptoms so as to earn his living; or, in view of the extension of the Workmen's Compensation Act, a sailor known to be the subject of heart disease or aneurism trying to pass himself off as a healthy man and fit for work. How often too do men and women of the middle class, also those of good society, pretend to be the victims of serious injuries after even mild railway accidents! There is a nervous condition left after the shock which partly explains this. Self-inflicted wounds, too, and mutilations are not unknown in the arena of forensic medicine. In Britain there is not, so far as I know, any law which inflicts punishment upon men and women for simulating disease for fraudulent purposes, but in France, Prussia, and Austria the law can deal with such. Both mental and physical ailments can be simulated. Epilepsy, true or false, and attributed to industrial conditions, is not always easy of differentiation. There is no ONE symptom by which mock or simulated epilepsy can be recognised. The *tout ensemble* must be considered. It is always difficult to appraise at their proper value symptoms that are purely subjective. Headache is just such a symptom. A man who has received an injury to his head may for months afterwards complain of headache which unfits him for work. There are frequently no physical signs by means of which the statement can be corroborated or disproved, for it is purely a sensation on the part of the patient. It is never wise to totally disregard the complaint of a patient, for after severe injury to the head there may develop a limited meningitis or possibly a tumour, either of which

may be causally related to the injury. On ophthalmoscopic examination the detection of neuro-retinitis would be of considerable assistance in guiding the medical examiner to an affirmative opinion in regard to an organic cause for the headache, but the absence of retinal changes would not necessarily point to the headache as having no existence except in the imagination of the patient. The urine in such cases ought to be examined for albumen, and the possibility of uræmia excluded. In the consideration of a paralysis complained of by persons who have received injuries, the co-existence of extensive anæsthesia along with the loss of muscular power would suggest a hysterical or inhibitory cause, and not an organic lesion, provided, of course, that such an accident had not happened as the division of a nerve. None the less, too, the hysterical condition observed in a patient might be just as much the result of an accident and nervous shock as a cerebral lesion itself, and a similar remark applies to the complaint of loss of sight in one-half of the eye and to loss of speech. To be the consequence of a structural lesion there would have to be additional signs, and these are absent in hysteria and neurosis.

It is more difficult to set a proper value upon *paresis*, or incomplete loss of muscular power, owing to its subjective character, than upon paralysis. Simulated paralysis like that due to hysteria frequently disappears and reappears—it comes and goes. It is characteristic of the hysterical paralysis that comes on after an injury that the symptoms do not correspond with anatomical and physiological facts. During the stage of excitement that occurs when an anæsthetic is being administered to any one who is the subject of traumatic hysteria the paralysed limb is often lifted and moved quite well by the patient.

Spasm and contraction of limbs frequently occur after fractures as the result of the broken bones having been too long in splints. The joints feel as if fixed and tightened. Under an anæsthetic the contracture, if it is organic, remains. In hysterical spasm of the hand, for example, where the fingers are drawn forcibly towards the palm, these can be lifted up by the medical examiner, who will feel the small

tremors of the muscles gradually give way; but if the spasm is simulated, *i.e.*, is voluntary, and is kept up by will, the individual cannot help making muscular contractions, and these are irregular and are felt.

Occasionally symptoms of a severe and lasting character develop after an injury. A man or woman after an accident becomes, for example, paralysed in the left arm and leg, also in the left side of the face, although in the circumstances of which I speak the face is usually unaffected. It is extremely difficult at first to say whether the loss of power on the one side of the body is functional or the result of an organic cause. The absence of heart and kidney disease and of a history of syphilis, also the normal appearance of the optic disc and retina in a person who has received an injury, and in whom the symptoms came on a few days after the accident, suggest a functional origin for the disease, a diagnosis which is strengthened should the loss of power be more pronounced in the leg than in the arm and be accompanied by loss of sensation, *i.e.*, anæsthesia and analgesia in the affected limbs. In hemiplegia, consequent upon a block or rupture of a cerebral blood-vessel, hemianæsthesia seldom accompanies hemiplegia. When, therefore, in addition to hemiplegia there is anæsthesia, which involves the left half of the tongue and buccal mucous membrane as well as the limbs, and is attended by defective sight and hearing or by continuation of the loss of sensation, while the motor power of the limbs is improving, the functional nature of the illness is almost assured, even if there is distinct evidence of a certain amount of facial paralysis present at the same time. A hæmorrhage into the posterior part of the internal capsule might involve both motor and sensory fibres, so that hemianæsthesia could quite well accompany hemiplegia. It would be necessary, therefore, to make a careful study of the field of vision, since in functional cases incomplete loss of sight is often complained of. A lesion of the right internal capsule which interferes with sight produces a left homonymous hemianopsia. The visual defect would involve half the field, or be hemiopic and not concentric. C. O. Hawthorne ("Functional Hemiplegia," *Clinical Journal*, Dec. 12, 1906) maintains that "defective

acuity (amblyopia) and a contracted field when associated with and on the same side as a hemiplegia (and therefore 'opposite' or 'crossed' in reference to the site of the presumed cerebral disturbance) are in the highest degree suggestive of a functional explanation of the paralysis." To the above add dislocation of the natural order of the colour fields, the circles of which are nominally from without inwards blue, red, and green, and the functional nature of the malady is confirmed.

Pain in the back and spinal tenderness elicited on pressure, are often hysterical; so, too, may be a lateral deviation of the spinal column, which examination under an anæsthetic clears up. On the other hand, pain in the lumbar region of the spinal column may undoubtedly be the result of severe strain caused by lifting a heavy weight, and be due to rupture of muscular fibres or stretching of spinal ligaments followed by effusion around nerve fibres. Spinal caries may even be the result of such a strain, and of this in its earliest stages pain may be the only symptom. As regards Pott's disease, injury may be directly or indirectly a cause.

Diabetes insipidus not infrequently follows injury to the back of the head. I have known it occur in men who, when at work, had fallen, and in their descent had knocked the head against a beam of wood or piece of iron. A few days afterwards, when consciousness had been regained, some of the men asked for water to drink, and exhibited a thirst difficult to satisfy. The polydypsia has invariably been followed by polyuria, which persists, and diabetes insipidus is the consequence. This illness, of which the outward sign is the elimination of several pints—10 to 20—of pale urine in the twenty-four hours, might well be simulated by men drinking large quantities of water. Under such circumstances the patient would have to be kept under observation for a time and carefully watched. One sign in particular would help to a diagnosis of traumatic diabetes insipidus, and that is the presence of structural changes in the optic disc in the direction of atrophy, not necessarily accompanied by marked loss of vision. The need of keeping also under strict observation

a patient who is said to be suffering from diabetes mellitus, the supposed result of an accident, is apparent, since people have been known to add sugar to their urine so as to simulate diabetes.

Hæmoptysis, or blood-spitting, is frequently simulated. All manner of deception is practised to gain a particular end. The chewing of raw liver is not unknown, or the mixing of blood with expectoration. I have found the roof of the mouth and soft palate of patients the seat of numerous bleeding points caused by the puncture of needles self-inflicted. Careful examination of the throat and nose in suspicious cases should be made to eliminate these as the sources of blood spitting. Auscultation of the lungs is always necessary, the possibility of pre-menstrual pulmonary hæmorrhage in females, however, being borne in mind. Every hæmoptysis is not a sign of tubercular disease of the lungs. There is a stage in pulmonary phthisis in which hæmoptysis can occur without any sign of tuberculous disease in the lung. It is more than probable that a limited patch of tubercle is present in the lung in many of these cases, but it is quite consistent with good health. Chavigny[1] says that there exists an affection which simulates in such a manner the hæmoptysis of the pretubercular period that a medical man runs the risk of confounding the one with the other, or he is led to make a diagnosis of simulated hæmoptysis when, notwithstanding numerous and periodical expectorations of blood, the health remains good and the lung free. To this condition Josserand[2] in 1893 gave the name of *hæmosialemesis*—a condition of an undoubtedly hysterical nature, yet supervening after an injury. The expectoration has special characters by which it can be recognised. The liquid contents of the spitoon should be emptied into a conical glass and allowed to stand for twenty-four hours, when it will be found to be divided into three layers. The uppermost layer, which is the most important, is very red; it is rich in hæmoglobin but poor in red blood corpuscles. The middle layer is not so highly coloured:

[1] "Diagnostic des Maladies Simulees," P. Chavigny, 1906, p. 407.
[2] *Lyon Médical* 1893, p. 219.

it appears as a thin, pale, rose-red disc; while the lowest layer has a greyish red appearance, and is made up mostly of epithelial cells and decolourized red corpuscles. Nicolai applies the term "pulmonary hysteria" to those cases in which, owing to hæmoptysis of the type just mentioned, the diagnosis of tuberculous disease has been made by even good physicians. In any case in which the particular features of hæmosialemesis are present the examination should be directed to ascertaining whether other hysterical stigmata exist. A bacteriological examination of the sputum ought also to be made, care having been taken—especially in a hospital—to prevent the patient mixing his sanguinolent expectoration with the sputum from a tuberculous subject. This examination is only of value when positive results have been obtained. We are scarcely warranted in applying the tuberculine test in these cases. While pulmonary phthisis is simulated, it is more frequently dissimulated or concealed. Men hide the fact as far as they possibly can in order to be allowed to follow their occupation.

Heart disease and injury form an interesting subject from the Workmen's Compensation point of view. I do not refer to complaints of palpitation of the heart and of a sense of cardiac distress by men who seek to palm off their complaint as the result of an accident when, in all probability, it is the consequence of sexual excess and over-indulgence in the use of alcohol and tobacco; nor do I allude to valvular lesions of the heart other than those connected with the aortic orifice, and disease of the aorta itself. Sudden strain and injury are capable of causing cardio-vascular lesions which may permanently disqualify the individual for work. It is a debateable point as to whether physical strain is capable of causing an aortic lesion in the absence of pre-existing disease of the valves or of the wall of the aorta itself. Medical opinion leans to the theory of some previous weakness due to age or the result of alchohol, but especially to syphilis, or to the two or three combined. Were there no exposure to severe and unexpected strain the weakened heart and aorta of the middle-aged workman would probably serve his purpose quite well for many years to come. My own opinion is that it is quite possible

for a comparatively healthy heart, free from valvular disease, to be taken unawares during severe strain, so that an injury is inflicted whereby either an aortic aneurism develops, or there is produced regurgitation through the aortic valves. The lesion is certainly traumatic, for at the autopsy the torn but otherwise healthy valve can be found. Aortic regurgitation originating under these circumstances is an accident for which a claim under the Workmen's Compensation Act might quite honestly be supported, provided always it was known that previous to the strain the aortic valves were healthy. I have known several instances of men whose heart was presumably healthy, for in them, although sought for, no cardiac bruit had been detected, becoming suddenly seized with precordial pain and faintness after lifting a heavy weight, and in whose chest a little time after the accident an aortic diastolic murmur could be heard. Traumatic aortic regurgitation has certain features that distinguish it from incompetence, the result of chronic endocarditis. The illness, for one thing, runs a much more rapid course; it is more quickly fatal and less liable to be compensated. Many of the patients, the subjects of this accident, die within two years of the injury. Aortic incompetence cannot be simulated, but a workman who is suffering from this malady might claim compensation for an alleged injury received at work which previous knowledge of the heart of the individual by his medical practitioner, especially as regards alcoholic excesses and syphilis, with a statement of previous illnesses, might fail to support. It must be borne in mind that heart disease, of even the most dangerous nature, *e.g.*, aortic regurgitation, can exist for years and not give rise to symptoms until some sudden strain is experienced or some intercurrent illness, such as bronchitis, arises to break the balance of the circulation.

Digestive Troubles, Vomiting, Colic, &c.—The extension of the Workmen's Compensation Act so as to include metallic poisoning is bound to give rise to litigation between employed and employer. Vomiting and colic, although frequent and very important symptoms of lead poisoning, are symptoms of such a large number of other diseases that care will

match-box. The match heads contain potassium chlorate, or chromate, and other compounds rich in oxygen, from which the oxygen required to induce conflagration is evolved. Although the Swedish matches made from red phosphorus are safer, both from the poisonous point of view and from danger of fire, the fact remains that until recently only three and a half tons of red phosphorus were used per year in Great Britain in the manufacture of matches, whereas sixty tons of white phosphorus were consumed.

The manufacture of white phosphorus is a small industry. It is carried on at Oldbury, near Birmingham. Few of the men employed have suffered in health, owing largely to the precautions that are observed and the fact that, as the substance is prepared in closed vessels, the workmen are not brought into direct contact with it. White phosphorus is used in the manufacture of the ordinary strike-anywhere matches. The match industry is an important one. The twenty-two match manufactories in Great Britain give employment to upwards of four thousand persons, of whom three-fourths are females. It was the death of a lucifer match maker in London about eleven years ago, and the announcement in the daily papers of a considerable amount of ill-health in lucifer match makers, that brought the subject of industrial phosphorus poisoning before the public and gained for the trade an unenviable reputation. Out of the human suffering that was then experienced and the stigma under which the trade laboured good has come. The subject, after having been much discussed in Parliament, was referred by the Home Secretary, Sir Matthew White Ridley, to a small committee, composed of Prof. T. Thorpe, of the Government Laboratory, Dr. Geo. Cunningham, and myself, to make an inquiry into and report upon (1) the nature and extent of the dangers attending the use of yellow and white phosphorus; (2) the means whereby these can be lessened; and (3) the practicability of discontinuing the use of yellow and white phosphorus. The report to the Home Secretary is published as a Blue Book.

The malady of the lucifer match maker that is most dreaded is what is known in this country as phosphorus necrosis, or "phossy jaw," and in France as *mal chimique*, a

localised inflammatory affection of the jawbone, extremely painful in the early stages, which lasts a long time, and invariably ends in death of the bone. As it is only within the last few years that cases of phosphorus necrosis have been reported to the Home Office, it is difficult to say how many lucifer match makers in this country have suffered. The total number of cases of industrial phosphorus poisoning reported in this country until the year 1899 was 102, of which nineteen were known to have terminated fatally. Three other cases occurred in 1900, so that 105 cases of phosphorus necrosis are known to have occurred during the latter part of last century. Since then only eight or nine fresh cases of phosphorus necrosis have been notified.[1]

The origin of the lucifer match is shrouded in obscurity. Several countries compete for the honour. There is the statement that the first lucifer match was made in Stockton-on-Tees. I have taken some pains to investigate this matter, for until recently I was of the opinion that lucifer matches were invented in Vienna; but it would now appear as if the Austrian capital had been in the early years of the match trade rather concerned with the production than the discovery of lucifer matches. A closer study of the subject leads me to regard England as the home of the industry, and John Walker, a dispensing chemist of Stockton-on-Tees, as the inventor of the lucifer match. Almost for equal recognition stands out Sir Isaac Holden, M.P. Mr. Walker died at 12, The Square, Stockton-on-Tees, May 1, 1859, at the age of 78. For several years before his death he had realised a good income from the sale of his matches. I have seen facsimiles of the matches. They are narrow, flat, wooden splints, 3 inches in length, and have a red-tipped head ¼ inch in length. The matches were sulphur-tipped as well. Walker's first friction matches were made of cardboard, and were sold at the rate of fifty matches for a shilling. Subsequently he substituted wood for the cardboard. A piece of sandpaper shaped like a

[1] Dr. T. M. Legge, Medical Inspector of Factories, informs me (Dec., 1907) that since 1900 inclusive there have been twelve cases of phosphoros necrosis notified, and of these five proved fatal. In Great Britain all cases of phosphorus necrosis, whether mild or severe, are reported. It is this circumstance which renders a comparison between British stat istics and those of other countries difficult.

cocked hat was sold with the matches, into which the match was inserted and drawn quickly to get the necessary explosion. Walker's books are still in existence, and in these are contained entries of sales with the names of the purchasers and dates. From these books we learn that he was making matches for sale in 1827. Sir Isaac Holden has been credited with priority as to the invention; but in an autograph letter dated May 2, 1892, Sir Isaac says his own match was not invented until November, 1829, and that at this date he was not aware of Walker's discovery. Sir Isaac (then Mr.) Holden never attached to his own invention the importance he might, nor did he take out a patent for it. In the *Leeds Mercury*, January 1, 1894, is a detailed account of a meeting held at Oakworth House to present Sir Isaac Holden, Bart., M.P., with an address from his constituents of the Keighley Parliamentary Division of Yorkshire. In the course of his reply the venerable parliamentarian said he had almost given up claiming any credit for the invention of lucifer matches, as he had been anticipated in that discovery by another inventor by about two years. By this renouncement of the claim the honour of the discovery rests with John Walker, the dispensing chemist of Stockton-on-Tees, whose body is buried in Norton Churchyard, a mile and a half from Stockton. Walker was never the recipient of any Royal favour, nor during his life was any special notice taken of the great service he rendered to mankind. As with other discoveries, many minds were directed to the same subject at the same time. Walker outstripped others both at home and abroad, and was selling matches in Stockton years before they were being made and sold in Vienna. Stephen Römer, a merchant in Vienna, is believed to have been the first to have made phosphorus stable in the air and incandescent by friction when mixed with incombustible substances. Römer is supposed to have bought the invention from a young Hungarian, Bartholomäus Irinyi, who was a student of chemistry at the time in Vienna. This was in 1832. France has also advanced a claim to the invention. Whatever doubt surrounds the origin of the lucifer match, it was certainly in Austria that in the fourth decade of last century the manufacture became an industry on a large scale. For a period Vienna controlled

the markets of Europe. The manufacture of matches had gone on for a few years without any mishap occurring, until 1838, when Dr. Lorinser, of Vienna, diagnosed phosphorus necrosis in a female worker, Marie Jankovits. This is the first authentic case of industrial phosphorus poisoning on record. Three years previously the manufacture of lucifer matches had been forbidden by several of the German States as being too dangerous, not so much to the health of the workpeople as to the safety of the community on account of fire. Shortly after 1838, Dr. Knolz having reported other cases of the malady, the Austrian Government appointed a commission to make an inquiry into the conditions of work in the seven match factories that at the time existed in Vienna. Although certain recommendations were made by the committee and were given consent to by the States Council in 1846, they never became effective, for between 1866 and 1875 there occurred 126 cases of phosphorus necrosis in the hospitals of Vienna alone.

That is the story as it bears upon Austria, and to which, as concerns its industrial aspects, we shall immediately return; but, as already stated, other countries had advanced a claim to having invented the lucifer match. England's share in the discovery has never been fully recognised, hence these details of the invention. In 1831 Charles Sauria, a student at the College of Arc, at Dôle, showed that matches could be made from a mixture of phosphorus, sulphur, and chlorate of potassium; but as he had no money to proceed with his invention, he detailed the processes of manufacture to his teacher of physics, Professor Nicolet, who in a moment of enthusiasm for his pupil carried the information to Johann Friedrich Kammerer, then a political prisoner in the Hohenasperg of Wurtemberg, who subsequently established a match works in Germany. Meanwhile Sauria, having finished his studies, had settled down as a doctor of medicine in St. Lothain, in Jura; but as he was not successful in the practice of his profession, an appeal was made by friends in 1884 to M. Jules Grèvy, President of the French Republic and a compatriot of the inventor, for pecuniary assistance to Sauria, who, after enjoying the pension a few years, died in 1895 at the age of 84. Sauria's lucifer match was far from being

perfect. Binoxide of lead was substituted by him for potassium chlorate in order to soften the character of the explosion on striking the match. In the works carried on by Sauria, as phosphorus necrosis was not unknown among the workmen, an attempt was made to eliminate phosphorus altogether from the factory, and to make lucifer matches out of chromate and chlorate of potassium, peroxide of lead, and sulphide of antimony. In 1902 old students of the College of Arc appropriately placed on record on a commemorative tablet the invention by Sauria, while the town of Dôle, the birthplace also of the illustrious Pasteur, named one of its streets after him.

Between 1835 and 1845 the production of lucifer matches increased with great rapidity over the whole of Europe. At the latter date, according to the interesting historical information supplied by Dr. Ludwig Teleky,[1] there were in Nuremberg four match factories, giving employment to 150 to 200 workmen, and three factories in Lyons. There were also works in Berlin, Stuttgart, Zurich, Strasburg, and Paris, but as a manufacturing centre Vienna remained supreme. The three large factories of Römer, Preshel, and Siegl in Vienna had a large export trade, in which smaller factories shared. As the smaller works, for want of capital, could not compete with the larger and better equipped, the smaller places gradually dropped out of existence, a fate from which the larger works were subsequently also not spared, for by 1854 there were only eight factories in Vienna and Lower Austria, giving employment to 280 men and 1,450 women. Even at this period attempts were being made to find in potassium chlorate a safe substitute for the dangerous white phosphorus. The match industry in Vienna gradually declined, but not on account of the character of the products, for at the Paris Exhibition in 1855 the three first prizes awarded for lucifer matches went to Vienna. In consequence of the dearness of the wood required for the splints the industry migrated to Bohemia and Styria, where wood was cheap, and where, as also in Galicia, it still gives employment to large numbers of persons. In 1855 Austria exported two

[1] "Die Phosphornekrose Ihre Verbreitung in Österreich und Dehren Ursachen." Wien, Franz Denticke, 1907.

million florins' worth, or 22,000 cwt. of matches; in 1866 the export trade reached its highest point, viz., 57,000 cwt. From this date the Austrian manufacture of matches has steadily declined in the face of Swedish competition, with its cheaper wood, and the imposition of high protective duties by countries to which Austria had hitherto exported. For wood, which in Sweden cost only four to five florins, the match manufacturers in Bohemia had to pay seventeen to eighteen florins, while Sweden, with its easy access to the sea and cheaper freights, gradually captured markets previously held by Austria. This has certainly been the case as concerns the Eastern Asiatic and China markets, where, too, within recent years, a formidable opponent has arisen in the commercial activity of Japan. The rise and fall of the Austrian match industry is an interesting social and international study, since to-day there is no longer even one match factory in or near Vienna. What part in the future Japan will play as a competitor in the lucifer match industry it is impossible to say. Her maritime ascendancy and proximity give her special privileges so far as the Chinese and even Indian markets are concerned, while the cheapness of wood in the island, the low wages, children's labour, and low freights enable her to compete in even distant markets with some of the older lucifer match-producing countries of Europe. In 1904 Japan produced 28 million francs' worth of matches, and gave employment to 21,400 workpeople (6,070 men and 15,335 women and young persons); whereas Great Britain, with her eighteen factories in 1901, gave employment in this industry to 3,100 women and 1,500 young persons. The following table, taken from Dr. Teleky's monograph, is not without interest in support of the opinions that have just been expressed and the facts stated. In the lucifer match industry—

Japan	employs	21,400	workpeople.
Russia	"	15,668	"
Italy	"	6,700	"
Sweden	"	5,655	"
Germany	"	4,815	"
Austria	"	4,611	"
Hungary	"	2,175	"
Great Britain	"	4,150	"

In 1905 Japan, with her production still increasing, sent to Australia and the United States of America 23,000 francs' worth of matches, and 13,400 francs' worth to Egypt.

When a member of the Lucifer Match Committee, it was my duty and privilege to visit match works in England, Scotland, Belgium (including Flanders), France, and Germany. Most of the recently built factories are up-to-date buildings, but there are a few that are quite out of keeping with modern requirements. It was because the manufacture of lucifer matches at the commencement of the industry required, practically speaking, no machinery, but only a small amount of plant, and matches were made by hand, that any kind of dilapidated building seemed to be considered good enough for the purpose of a match factory. Hence the wretched structural conditions of some of the factories I have visited, also the circumstance of the manufacture of lucifer matches being clandestinely carried on as a domestic industry and attended by serious consequences to the workers.

Most countries have consumed the matches manufactured within their own borders, but others, such as Norway, Sweden, Belgium, and Great Britain, have been large exporters as well. Japan, as already stated, manufactures and exports a large quantity of matches. It is difficult to ascertain to what extent lucifer match making is a home industry in Japan. Two kinds of matches are made there, (1) the ordinary strike-anywhere, and (2) safety matches. The work is carried on under certain regulations. There are no such factory laws in Japan as we have in this country, and yet among the requirements it is insisted that there shall be a separation from each other of the different departments, namely, dipping, drying, and boxing, the provision of ventilation by hoods and fans, the prohibition of employment of persons when their teeth are decayed, the interdiction of food taken into and eaten in the factory, and of the presence of a larger percentage of phosphorus in the paste than 10 per cent. In Japan no match factory can be built without the consent of the Government, and no workers can be employed under sixteen years of age.

The head of an ordinary strike-anywhere match contains

glue, phosphorus, chlorate of potassium, powdered glass, and magenta, or some such colouring agent. The paste, or "composition," contains on an average 5 per cent. of phosphorus. Into this compound, when spread out moist and slightly warmed, one end of the wooden matches, or splints, is dipped, several hundreds of them at a time. These are then taken to a drying chamber. After drying, the frames containing the matches are stripped and the matches are boxed. It is in the mixing of the paste when done by hand in open vessels, and in the dipping and boxing of matches, that the workpeople are exposed to fumes that become a menace to health. The mixing of the paste ought always to be done in closed vessels, mechanically if possible, and the dipping and boxing of the matches carried on close to a running fan. During the process of dipping, the fumes of the phosphorus are quite visible. They can be seen rising for a few inches above the dipping plate and travelling towards the fan. These fumes are rich in phosphorous oxides. Professor Thorpe exposed decayed human teeth to the fumes of phosphorus for twelve hours, and he found that they lost 0·37 per cent. of their weight, and that carious teeth when exposed to a dilute solution of phosphoric acid (1 per cent.) lost 8·9 per cent. of their original weight. The atmosphere of an ill-ventilated lucifer match factory simply reeks with the garlicky odour characteristic of phosphorus. Thorpe found 0·02 milligramme of phosphorus in 100 litres of air in the dipping room of a match factory, and in the same quantity of air in the boxing room 0·12 milligramme of phosphorus. Since during several hours of each working day the dippers and boxers are inhaling this poisoned atmosphere, the fumes become dissolved in the saliva of the mouth and exercise a solvent action upon the teeth. It is not alone the air breathed that is the source of danger. The poison clings to the fingers and hands of the workpeople. On examining the hands of a boxer they are seen to be deeply stained by the dye given off by the heads of the matches, and they emit the characteristic garlicky odour. They glow in the dark. On analysing the water in which twenty-two workpeople had washed their hands on

leaving the factory, Thorpe found 37·3 milligrammes of phosphorus, an amount equal to 4·2 milligrammes of phosphorus per person for each ten hours' work.

Phosphorus necrosis, or phossy jaw, is the unique malady of lucifer match makers. It is a localised manifestation of phosphorus poisoning. That the system, generally speaking, is also affected as well is more than probable. French physicians describe a general morbid condition of the body, or a cachexia, met with principally in female workers, characterised by pallor of the face, dyspepsia, albuminuria, and a tendency to bronchitis, to which the term *phosphorisme* has been applied. During my visits to the French match works I had the opportunity of discussing with Dr. Arnaud, of Marseilles, the liability of young female workers to bronchitis, as it is not a common affection in this country. In his opinion 28 per cent. of the young women suffered from bronchitis, but there was no tendency for the disease to become tuberculous. Arnaud did not find, as some French physicians have maintained, that there is a greater predisposition on the part of the pregnant lucifer match maker to miscarriage than women employed in other occupations. My experience confirms that of the Marseilles physician. This is an interesting and important point, because phosphorus in the form of a decoction of match heads is frequently resorted to by women for the purpose of inducing abortion, always with extremely painful consequences, and often with a fatal result.

In Great Britain *phosphorisme*, or the constitutional form of phosphorus poisoning, is not of common occurrence. The malady that is dreaded is phosphorus necrosis. The presence of decayed teeth predisposes a match maker to the disease, for the phosphorus fumes penetrate carious teeth, and readily induce a periostitis, or acute inflammation of the covering of the jaw-bone. The gum becomes swollen, and both it and the jaw-bone painful. Sooner or later pus forms, and although the tooth, or teeth, are extracted, the pain continues, but in a less severe form. The inflammation gradually extends to the bone, which undergoes a process of slow destruction. For months pus keeps oozing out into the

mouth in minute quantities, some of which is swallowed, and tends to induce a chronic toxæmia. By means of the use of antiseptic mouth-washes the morbid process gradually ceases by a piece of dead bone being thrown off, or the decayed bone is removed by surgical operation, when the patient recovers, with or without facial deformity.

Opinions are divided as to the cause of phosphorus necrosis in lucifer match makers. Is it the result solely of phosphorus fumes acting upon the jaw-bone through decayed teeth setting up inflammation of the bone, and allowing therefore the micro-organisms present in the mouth to carry the morbid processes further; or is phosphorus necrosis, as Professor Stockman, of Glasgow, informs us, a tuberculous affection of the jaw-bone, and due to infection by the tubercle bacillus? My own opinion is that the disease of the bone is the result of a mixed infection, and that phosphorus fumes, by primarily inducing pathological changes in the teeth and jaw-bone, make it possible for micro-organisms to carry on their baneful operations.

There is, however, something peculiarly human in phosphorus necrosis. Dr. L. v. Stubenrauch, of Munich, tried to produce phosphorus necrosis in dogs by exposing them to the vapours given off from burning phosphorus, but without any untoward results. Other dogs, some of whose teeth had been extracted, were exposed in the boxing rooms of large match factories for six months without any evil consequences. Experience and experiment alike show that it is practically impossible to reproduce in animals the picture of phosphorus necrosis exhibited by man. Stubenrauch maintains that the first stage in the morbid process is thrombosis of the small blood-vessels of the bone (*Archiv. f. Klin. Chir.*, Berlin, April 7, 1899). Lewin, of Berlin, does not believe that it is primarily necessary for a lucifer match maker to have decayed teeth. The phosphorus fumes, in his opinion, inflame the gums in the first instance, and as a consequence there is induced a septic gingivitis, which is followed by disease of the bone. In Wegner's experiments with phosphorus upon animals the cancellous part of the bone became hard and sclerosed. Although phosphorus has some special

predilection for bone, the fact that in animals exposed to it necrosis of the jaw-bone does not follow suggests that in the human subject there is probably, over and above phosphorus fumes, some other factor in operation.

Phosphorus when absorbed is only slightly altered in the blood. When exposed to the air phosphorus is slowly oxidised, but this occurs hardly at all in the blood-vessels. If, for example, to freshly drawn arterial blood phosphorus is added, and the glass tube is hermetically sealed, the bright red arterial colour is not lost earlier than in a control experiment where none of the metalloid is used. Phosphorus, therefore, cannot be said to absorb oxygen from the blood, so that the amount of phosphoric acid formed in the blood must be too small to cause poisoning. The blood loses its power of clotting, probably owing to the action of phosphorus upon the blood ferment.

Lucifer match makers are liable to another affection of the bones, one which has a special relation to the constitutional effects of phosphorus poisoning. When visiting the match works in Grammont, Belgium, I had the opportunity of meeting Dr. Brocoorens, who has had large experience of match makers and their diseases. He drew my attention to the fact that several of the men who had been employed as dippers in the factories, and who in their earlier years had suffered from phosphorus necrosis and had recovered, exhibited an unusual tendency to fracture of their long bones, especially the femur, often on the slightest exertion. The town of Grammont contains six match factories, which give employment to upwards of 1,100 persons. During the thirty years Dr. Brocoorens has resided there he has treated upwards of thirty cases of spontaneous fracture of the long bones consequent upon such simple muscular effort as that required when walking to lift the foot from the roadway to the pavement. Spontaneous fracture of the bones has not occurred in England with anything like the frequency as in Belgium, but Dr. Garman, of Bow, for many years medical officer to Messrs. Bryant & May's works, informs me that he has known of nine cases, and Dr. Dearden, of Manchester (*Brit. Med. Journ.*, 1899, vol. ii. p. 270), has reported the

occurrence of the accident in two dippers, "each of whom has had separately and at different times both thighs broken in a ridiculously simple fashion." Dr. Kocher, of Berne, has had experience of a match maker who broke his thigh-bones five times. The readiness with which the long bones snap in match makers indicates that the bony tissue is in some way or other influenced by phosphorus or its compounds, whereby they are unable to withstand external violence. It is Dearden's opinion that the bones of match dippers contain an excess of phosphoric acid, which combines with the pre-existing neutral phosphate of lime to form a slightly acid salt and thereby to cause the *fragilitas ossium* of lucifer match makers.

In Great Britain less than 1 per cent. of the match makers have suffered from phosphorus necrosis, in Switzerland it was formerly 1·6 to 3 per cent., and in France 2 to 3 per cent. Of 51 cases of phosphorus necrosis communicated to me by Dr. Garman 9 ended fatally. Eighty-three per cent. of his patients recovered and returned to work. Of the 51 cases 31 were females and 20 were males. In the women the upper jaw was affected 15 times and the lower 16. In the men the numbers were respectively 11 and 9. Dr. Brocoorens found that the dippers were more liable to necrosis of the upper jaw, and that in boxers, who are usually females, it was the lower jaw that was more frequently affected. When phosphorus necrosis has attacked the upper jaw the inflammatory process is apt to extend to the brain and induce a septic inflammation, which in every instance has been fatal. A person may follow his occupation in a match works for years without suffering, or he may have left the works for two years or more when unexpectedly symptoms and physical signs of phosphorus necrosis show themselves. The ages at death of Garman's patients were 19, 19, 21, 22, 22, 22, 23, 27, and 27. It does not always require an exposure of many years to the fumes of phosphorus for a fatal result to follow. In two of the patients included above pulmonary consumption doubtless contributed to the fatal result.

The questions submitted by the Home Secretary to Pro-

fessor Thorpe and myself were briefly whether anything could be done to render lucifer match making from white phosphorus a more healthy employment and whether a harmless substitute could be found for the dangerous metalloid. Since it has been recognised that the fumes of white phosphorus by penetrating carious teeth must play some part in causing necrosis of the jaw-bone, periodical examination of the teeth of the workpeople by a qualified dentist, and treatment when necessary, improved ventilation of the workrooms, reduction of the amount of phosphorus in the paste for heading the lucifers, and suspension from the factory of all workers on the slightest appearance of symptoms, have done much to diminish phosphorus necrosis in match makers. Only twelve cases of phosphorus poisoning have been reported to the Home Office since 1900, and in three of these the disease probably existed before the new rules were drafted. The introduction of machinery whereby the wooden splints are cut, the matches dipped, dried, and boxed without being handled by the workers, has in the Diamond Match Works, Liverpool, been followed by the greatest success. When these processes are carried on in large, well-ventilated workrooms and the mixing of the paste takes place in covered iron vessels provided with ventilating shafts, the risk from phosphorus necrosis is considerably diminished. The fact remains, however, that so long as white phosphorus is used absolute freedom from risk to health cannot be assured.

Manufacturers have, therefore, been obliged to turn their attention to the use of a harmless substitute for white phosphorus. The difficulty at first was to produce a satisfactory strike-anywhere match, for valuable as the Swedish or safety match is, the public demand for this kind of match does not increase in the same proportion as for the ordinary lucifers. The workpeople on the Continent have suffered from phosphorus necrosis as much as, if not more than, our own match makers. Denmark, Switzerland, and Holland have for a few years interdicted the use of white phosphorus and the sale of matches made from it. These countries only manufactured for home consumption. They never exported to any

extent, if at all. In France, where the manufacture of matches is a State monopoly, and where the workers had to be compensated for injury to health in consequence of their occupation, the claims for compensation had a few years ago risen to such a height that the Government was obliged to make an effort to improve the lucifer match industry. Much of the ill-health complained of by the workpeople was doubtless in no way the consequence of their occupation. The figures are interesting. In the match works at Pantin-Aubervilliers, near Paris, there were reported 32 cases of phosphorus intoxication in 1894; in 1895, 125; in 1896 the number rose to 223, or one-third of the effective force of the factory. At these dates the paste for heading the matches often contained, in addition to small quantities of lead, 20 to 30 per cent. of phosphorus. In one year, January 1 to December 31, 1896, the State paid to the workpeople at the Pantin-Aubervilliers match factories 400,000 francs, or 630 francs per person employed over and above his wages. Apart from this undesirable drain upon the Treasury it was felt that the time had come when something would have to be done to alter the conditions of labour in French match works. Meanwhile the Belgian Government had offered a prize of 50,000 francs to any person who would invent a safety strike-anywhere match free from white phosphorus. France solved the problem. After many trials MM. Sevène and Cahen demonstrated that in sesquisulphide of phosphorus was to be found a substitute practically capable of accomplishing all that white phosphorus could do without causing symptoms of poisoning. These scientists gave daily 3 centigrammes ($\frac{2}{3}$rd grain) to guinea-pigs over a considerable period without producing symptoms of intoxication, whereas 3 milligrammes ($\frac{1}{25}$th grain) of white phosphorus similarly introduced killed guinea-pigs very rapidly.

It was thought at first that matches made from sesquisulphide of phosphorus would not carry well across the ocean and that they would not keep well in all climates, but experience has not confirmed these forebodings. The sesquisulphide is almost an inodorous powder, and is, prac-

tically speaking, non-poisonous. It may contain a trace of red or amorphous phosphorus and at times give off a slight odour of sulphur. The results of the substitution of phosphorus sesquisulphide for the harmful white phosphorus at Pantin-Aubervilliers were at once apparent in the improved health of the workpeople and in the cessation of monetary claims for injured health. Dr. Courtois-Suffit, Medical Inspector of the French match factories, informs me that lucifer match making is no longer regarded as a dangerous trade by his Government. The sesquisulphide has found its way into Great Britain, and its use has been followed by success. One good, but quite unexpected result of the substitution of the harmless for the dangerous form of phosphorus in match making is the diminution in the severity of symptoms and in the number of cases of fatal suicide due to the use of matches. Phosphorus poisoning, which was the cause of a few deaths every year in the Royal Infirmary, Newcastle, has, practically speaking, disappeared from our statistical tables, and in the patients admitted the symptoms are usually less serious, a circumstance which shows that in this city, at any rate, the matches that are sold have been mostly prepared from the sesquisulphide. The paste from which these non-poisonous matches are made is as follows :—

Sesquisulphide of phosphorus	6	parts.
Chlorate of potassium	24	"
Oxide of zinc	6	"
Red ochre	6	"
Powdered glass	6	"
Glue	18	"
Water...	34	"

Since the introduction into France of the manufacture of the sesquisulphide match there has not been in the factories one case of phosphorus poisoning, nor has there been any explosion or fire in any of the match works. The slight trace of sulphuretted hydrogen given off by the new material has not produced illness of any moment. Readiness to catch

fire and the evolution of unwholesome gases have been prevented by the regulations requiring that the sesquisulphide shall contain 3 to 4 per cent. of red phosphorus; this prevents the formation of unstable subsulphides. In the manufacture of matches by phosphorus sesquisulphide, machinery is fast replacing hand labour, the economic advantages of which change are readily apparent, while the health of the workers is in all respects improved. For the last seven years the new method of manufacture has been in use at Pantin, where with the improved machinery 2,500,000 matches are made every day. This has reduced the number of workers employed, but it has purified the industry.

In our own country a similar improvement has been observed. Mr. Bartholomew, managing director of Messrs. Bryant & May's works, London, writes to me that "We are well satisfied with our long trial of the new composition. There has not been, and there cannot be, from the nature of the composition, any sickness among the workpeople." In the future we shall hear less and less of the frightful ravages of white phosphorus. The manufacture of lucifer matches is therefore an illustration of at least one industry which, from being of a dangerous and unhealthy nature, has become by vigilance and scientific invention comparatively speaking healthy. This change for the better has been secured without great cost to the manufacturers, for it has not necessitated any great change of plant, and yet what a gain it has been to hundreds of workpeople who have to earn their living in the trade!

Although in preceding pages sesquisulphide of phosphorus has been extolled as against white phosphorus, it is only right to mention that while its use in the manufacture of matches has so far been free from danger, it acts in some instances as an irritant, causing conjunctivitis and œdema of the eyelids, also eczema of the skin. To obviate this the workpeople in France engaged in the manufacture of the sesquisulphide bathe their eyes, and douche their nostrils, twice a day before leaving the factory with an alkaline solution of bicarbonate of soda, and since adopting this preventive line of treatment the inflammatory troubles have ceased to exist. At first the

workmen refused to adopt these precautionary measures, but this initial difficulty having been overcome the workpeople themselves are now feeling the benefit of them.

The treatment of phosphorus necrosis is mainly preventive. New workers on being taken on at the factory should be medically examined, special attention being paid to the state of their teeth. There ought to be periodical examination by a dentist of the teeth of all workers in a match factory, with power to suspend when necessary. Personal cleanliness is a requisite, and the frequent use of antiseptic mouth-washes a desideratum. The workrooms should be well ventilated, and fans should be running to withdraw all fumes away from the face of the workers. Washing accommodation should be ample, hot and cold water being provided along with plenty of soap and towels. On complaint of pain in the jaw, the mouth should be examined by a dentist, loose and carious teeth should be extracted and the use of antiseptic mouth-washes encouraged. Once phosphorus necrosis has developed the malady may be treated simply by keeping the affected part clean as far as possible by mouth-washes and by maintaining the general health of the patient by good food and fresh air; but healing is a slow process, for the disease may go on for several months before it is arrested or the piece of dead bone thrown off. To expedite recovery surgeons occasionally remove by operation the dead bone. Eighty per cent. of the cases of phosphorus necrosis recover, whether dealt with surgically or treated by antiseptic washes. The most fatal cases are those where the disease extends from the upper jaw into the base of the skull and sets up septic meningitis, or those in which, owing to rather profuse and protracted suppuration of the jaw-bone, pus keeps escaping into the mouth, mixes with the food, and causes toxæmia or gains access to the respiratory canals and lights up pulmonary disease.

The question of the total prohibition of white phosphorus has frequently been discussed. Elsewhere I have expressed the opinion that nothing short of its total abolition will render the manufacture of lucifer matches a safe industry from a health point of view, but there are economic and commercial considerations which cannot be altogether ignored

even in the lucifer match trade. Only by international agreement can this question be settled. At the Berne Congress (1906) the representatives of the British Government did not see their way to join in the abolition movement unless other large exporting countries co-operated. Readers need only refer to the figures and facts given in an early part of this chapter which deal with the rapid industrial advance of Japan, and to remember the unwillingness of Japan at the Berne Congress to co-operate with other countries in the movement for the abolition of white phosphorus, to find an explanation of the attitude assumed by the British representatives in regard to this subject.

In these pages I have dealt with the signs and symptoms of industrial phosphorus poisoning. When persons have accidentally swallowed phosphorus, or drunk a solution of match heads with suicidal intention, they have usually become jaundiced by the third day, and most of them have died shortly afterwards from toxæmia. After death the liver and kidneys have been found to have undergone fatty degeneration. Recently a child two years of age was admitted into the Royal Victoria Infirmary, Newcastle, who had sucked several match heads. She died within 30 hours of the event, and although she was never jaundiced, there was yet found at the autopsy advanced fatty degeneration of the liver and kidneys. The case is exceptional as regards the rapidity of death, absence of jaundice, and the presence of extreme fatty degeneration of the internal organs in the short time. The matches had been made in Flanders and contained white phosphorus. The case serves to illustrate this other important point—that should Great Britain interdict within her own borders the manufacture of matches from white phosphorus, Parliament would at the same time have to prohibit the importation of "strike-anywhere" matches made from white phosphorus; and while this might be done in the interests of the health of the people, it would be regarded by some persons as a form of protection to which, commercially at any rate, this country has not yet committed itself.

CHAPTER II

DISEASES DUE TO GASES, VAPOURS, HIGH TEMPERATURES, ETC.

Carbon Dioxide; Carbonic Acid (CO_2)

AS a poisonous gas carbonic acid can hardly be compared with carbon monoxide, (CO) the symptoms of poisoning by which develop with great rapidity. Carbonic acid is, fortunately, a more feeble poison. More people are brought under the influence of CO_2 than CO, since it is the gas which is present in badly ventilated dwelling-rooms, workshops, and factories. When exposed to small quantities of this gas for a long period the vital resistance of the organism is reduced and the way is paved for disease. CO_2 is found in ordinary atmospheric air to the extent of ·04 per cent., but it must be present in larger quantities to cause such symptoms of poisoning as headache, vertigo, buzzing in the ears, heavy sleep, and loss of consciousness. Three per cent. of CO_2 in the air causes difficulty of breathing, 6 per cent. causes palpitation and headache, while upwards of 10 per cent. induces unconsciousness. In poisoning by CO_2 the breathing is at first quickened: it is short and gasping, the beat of the heart becomes slower, the extremities cold and cyanosed, and death comes with or without a convulsion. It is the mode of termination of life in many cases of heart disease. There are few instances in which carbonic acid without the presence of other gases at the same time—*e.g.*, carbon monoxide—is breathed in sufficient quantity by men and women at work as to become an immediate source of danger. CO_2 is one of the impurities

of the air in tunnels and occasionally in coal-mines, but so long as there is an adequate quantity of oxygen present at the same time respiration can go on pretty well.

Our knowledge of the harmful effects of CO_2 has been largely obtained from Paul Bert, who showed that when the atmosphere in which an animal is placed is not renewed it dies. The tension of the oxygen falls until it is insufficient for the needs of respiration and there occurs anoxæmia followed by asphyxia. In closed spaces where CO_2 is allowed to accumulate and at the same time sufficient oxygen is introduced, the animals die when the CO_2 has become excessive, owing to the high CO_2 tension in the air preventing the escape of CO_2 from the blood. Cartell [1] showed that the heart of a frog beating vigorously would cease at the end of 10 minutes if plunged into an atmosphere of CO_2, whereas the heart of another frog would go on beating for 1½ hours if placed in an atmosphere of pure nitrogen, which is an inert gas. Liebeg and Paul Bert have confirmed the harmful action of CO_2 upon the muscular fibres of the heart. During respiration it is not so much the carbonic acid in the air breathed that is dangerous, as the CO_2 in the blood obtained from the tissues not being allowed to escape. CO_2 poisons both the muscular and nervous tissues.

There are few industrial operations in which large quantities of CO_2 are given off in a chemically pure form. The gas is evolved from vats in breweries during the fermentation of beer, and is present in the malt-house, the air of which should be renewed before entering. It is formed, too, during fermentation in starch works, is met with in paper works owing to fermentation of the paste, and in sugar refineries during the carbonisation of the juice of beet-root. Years ago it was a frequent source of accident and occasionally the cause of death of workmen engaged in making wine, from fermentation of the grape juice and the cleaning out of wine vats. CO_2 is given off from lime kilns, and is often present in unused cellars and in the galleries of mines.

Carbonic acid calls for attention since it is the gas which is present in the air of factories and workshops, and the per-

[1] "Encylopéd. d'Hygiène," p. 547.

centage of which is taken as a measure of the impurity of the air breathed by the workers. The Home Office regulations require 250 cubic feet of atmospheric air per individual during ordinary working hours, and 400 during overtime, *i.e.*, beyond a ten hours' day. Ordinary atmospheric air is composed of 20·93 per cent. of oxygen, 79·04 of nitrogen with argon, and 0·03 to 0·04 of carbonic acid, with a small quantity of water. The human body is constantly adding to the amount of CO_2 in the atmosphere of a factory, and when there is also added to this the CO_2 given off by artificial lights, the necessity for the frequent renewal of the air in factories and workshops is apparent. A tolerance to CO_2 is created, as is seen in the case of the poorer working classes, among whom there is overcrowding with little or no ventilation of their dwelling-rooms. The breathing of an atmosphere vitiated by carbonic acid is a cause of headache and a feeling of malaise to those who are unaccustomed to it. In the case of the poorer working classes it cannot but reduce their vitality and predispose them to disease. Expired air not only contains an excess of CO_2, it is ladened with certain volatile organic products which cause the air to have an offensive odour. It is this organic material in expired air which has a slight reducing power upon potassium permanganate, and is regarded by some physiologists as the poisonous material in the air. Haldane and Lorrain Smith did not find the injection into animals of large doses of water condensed from expired air followed by any bad effects, but Brown-Séquard and D'Arsonval [1] found that the volatile alkaloid contained in expired air, and to which they gave the name of *anthropotoxine* or *zootoxine*, was capable of causing the death of animals. It caused the death of 17 out of 18 animals when injected under the skin. When the liquid was injected into the lungs death came preceded by inflammation of those organs.

It is desirable to maintain a standard of purity of the air of factories. In 1897 Sir Henry Roscoe's Committee recommended a standard of 9 volumes of CO_2 per 10,000 of air for cotton cloth factories. This was considered lenient

[1] *Académie des Sciences*, February 11, 1899.

from the hygienic point of view. A Departmental Committee of the Home Office subsequently fixed the standard of carbonic acid as 12 volumes per 10,000 of air during daylight or where the electric light is used, and where gas or oil is used for illuminating purposes the proportion was not to exceed 20 per 10,000. The Association of Certifying Factory Surgeons, taking 4 volumes of CO_2 as the proportion in outside air, and 6 as the proportion in inside air, per 10,000, recommended that 9 volumes of CO_2, *i.e.*, 5 volumes of CO_2 per 10,000 in excess of that found in the outside air, would be a fairer proportion to allow during daylight and that double this amount might easily be allowed during gas light. From these divergent opinions and recommendations it is apparent that a fairly wide and reasonable margin must be allowed. It is not desirable on the one hand to adopt such a low standard of atmospheric purity as to perpetuate a bad condition of the air in factories, nor on the other hand is it wise to insist upon conditions that are with difficulty obtained by employers.

Under ordinary circumstances CO_2 is removed from the blood during expiration. The presence of the gas in the blood stimulates the respiratory centre so that deeper breaths are taken and the lungs are better ventilated. It is the partial pressure of the CO_2 in the pulmonary alveoli that regulates the ventilation of the lungs. At normal atmospheric pressure there is about 6 per cent. of CO_2 in the air spaces of the lungs. While CO_2 under ordinary circumstances does not cause any serious symptoms, it is otherwise when the gas is present in excess and an animal or man is breathing the gas in a compressed-air chamber, such as a caisson. I have found when small animals, *e.g.*, mice, have been exposed for half an hour or longer to 5 atmospheres of compressed atmospheric air containing 1 per cent. of CO_2, that while the animals on being taken out of the air chamber might appear to be somewhat somnolent and disinclined to move, they shortly afterwards recovered, but that many of them a few days afterwards, even as long as 10 or 12 days afterwards, died unexpectedly, and that the cause of death in some of them was acute inflammation of the lungs. In other

instances rats, which seemed to be quite well on being removed from the caisson, died a few hours afterwards, and as no naked-eye morbid appearances were presented by the various organs at the autopsy except slight congestion of the brain, death must have been due to poisoning of the nerve centres by CO_2. Excess of CO_2 in the air is probably more dangerous when breathed in the compressed form than at ordinary pressure.

Carbon Monoxide; Carbonic Oxide (*CO*)

Carbon monoxide, one of the products of the incomplete combustion of carburetted gas, also of coal and explosives, is met with in subterranean galleries, *e.g.*, coal-mines where blasting has been effected by dynamite or gunpowder. It forms 7 to 10 per cent. of ordinary illuminating gas and is the source of the blue flame seen on the surface of ordinary coal fires. The gas is given off in large quantities from coke ovens. It is to the breathing of this gas during sleep that the death of tramps drawn to the coke ovens by their inviting warmth on a winter's night is attributed. Carbon monoxide is *per se* a colourless and inodorous gas. It has an affinity for the colouring matter of the blood, varying according to physiologists from 140 to 250 times greater than that of oxygen. It forms a remarkably stable compound with the hæmoglobin, which is with great difficulty dissociated, and to which circumstance the extremely poisonous properties of the gas are due. The presence of such small quantities as 0·1 per cent. in air is sufficient to cause unpleasant symptoms, such as headache and a sense of tiredness attended with difficulty of walking. When the percentage rises to 0·4 the atmosphere becomes dangerous to animal life.

The gas is evolved from blast furnaces in the smelting of iron, the charging of furnaces and their tapping; also in the manufacture of illuminating gas, the Leblanc process of soda manufacture, in explosions in coal-mines, in cement and brick works, and in the making of tunnels.

As we are dealing in these pages with the effects of several poisonous gases, it may not be out of place to discuss here the general aspect of the subject from the physiological point of

view. The purpose of respiration is to carry oxygen into the body and to remove waste products from it, mainly carbonic acid and water. In ordinary respiration the oxygen of the atmospheric air enters into chemical combination with the colouring matter, or hæmoglobin, of the red corpuscles of the blood. The oxygen thus absorbed in the lungs is quite irrespective of pressure. From these corpuscles as they circulate with the blood, oxygen is given up to the tissues. In addition to the oxygen taken up by the colouring matter of the red blood corpuscles, a smaller amount of oxygen is also absorbed by the blood in accordance with Dalton's law of pressure. The oxygen absorbed by this method is so lightly retained that the whole of it will escape when the pressure falls below a certain level. Heat also favours the dissociation. Carbon monoxide is one of those gases which so act upon the blood corpuscles as to displace, volume for volume, the oxygen fixed by the coloured corpuscles, and having accomplished this the CO itself is so firmly retained by the hæmoglobin as to be displaced only with the greatest difficulty. A gas behaving in this manner is said to be toxic; it is a poison. The rapid action of poisonous gases can be readily understood when there is taken into consideration the enormous surface for absorption presented by the lungs, for in the myriads of their capillary blood-vessels the blood is brought almost into direct contact with the gas. Poisonous gases are of two kinds, (1) the purely toxic, illustrated by carbon monoxide, and (2) irrespirable gases. Both kinds cause asphyxia. For the respiratory functions to be carried on normally it is necessary that there shall be no obstacle to the blood reaching the lungs, also when there that it shall be brought into close contact with the inspired air. The blood corpuscles themselves must be healthy and be present in proper numbers to absorb oxygen. Many toxic gases act as a direct poison to the red blood corpuscles and unfit them for taking up oxygen; other gases destroy or irritate the lining membrane of the pulmonary alveoli, *i.e.*, the air spaces of the lungs. On the other hand a gas like pure hydrogen or nitrogen is irrespirable because it contains no oxygen.

Blast Furnaces and Carbon Monoxide Gas

Several cases of serious illness and a few fatalities have occurred during the charging of blast furnaces in ironworks and in consequence of the escape of crude blast-furnace gas from the flues. The open-top blast furnaces have been a frequent source of minor poisoning to the men who charge them. Through the kindness of Dr. C. Stanley Steavenson, of Middleton St. George, Co. Durham, to whose professional care the patients had been entrusted, I had two years ago the opportunity of seeing the effects of carbon monoxide poisoning upon two blast furnacemen. In these men there were at first great sleepiness and headache, followed by incomplete loss of power in the limbs, and on the subsidence of the acute symptoms it was observed that speech was affected, much in the same way as in general paralysis. There was a distinct articulation defect when I examined the men two or three months after the commencement of their illness. The power of walking properly had not been regained; the gait was slow and stepping, the grasp of the hands feeble, and the pupils were dilated. There were nystagmus (a peculiar oscillatory condition of the eyeballs) and a degree of nervous excitement and exaltation, such as is seen in the worst cases of hysteria. One of the patients would burst out into hilarious laughter now and again without the slightest provocation. The simplest questions addressed to him seemed to cause amusement. Although the general physique of these men is good, their nervous system has been so thoroughly poisoned by the blast-furnace gas that they are likely never to do any further work. In confirmation of this statement I have recently learned that the mental condition of these men remains the same although it is fully two years since their illness began. These records are extremely interesting, for there have been few cases published of such permanent effects having been left by blast-furnace gas. That the particular constituent of the blast-furnace gas which poisoned these men was carbon monoxide there is little doubt when attention is given to the analyses of the gas. Analysis of the gas on two occasions from the blast

furnace at which the men worked showed the presence of large quantities of carbon monoxide (CO).

	A.	B
Carbonic acid	4	7
Carbon monoxide	36	32
Hydrogen	2	5
Arsenic	0.1	—
Sulphur	trace	—
Nitrogen	58	55·3

In order to make a comparison between the gases given off by the blast furnaces in this particular neighbourhood and those from furnaces in another part of the North of England, I obtained, through the manager of one of our largest iron-works, the following analysis:

Carbonic acid	12·4
Carbon monoxide	27·5
Carburetted hydrogen	0·2
Hydrogen	2·7
Nitrogen	57·2

It cannot be anything but the high percentage of carbon monoxide that constitutes the danger in blast-furnace gas. This gas flows away at the end of a slag-tapping, and although present at that time in very small proportion, 1 per cent., it is liable to accumulate in dangerous quantities near the furnace boshes, so that isolated workmen ought not to be allowed to remain near the boshes when the blow-out period of slag-tapping takes place. Blast-furnace gas may escape through a crack in a flue, and penetrating the soil it loses its impurities and its odour as it passes onwards. It may find its way into inhabited houses and cause the death of the inmates. As an illustration of subtle poisoning by carbon monoxide gas I need only mention the following: At Pelton Fell, a mining village in Co. Durham, some shale which had been tipped at the edge of a ravine caught fire. The carbon monoxide gas given off during the combustion travelled through the soil, and entering two houses in different streets fully thirty feet away, caused the death of two elderly people

Inhalation of carbon monoxide causes headache and a sense of loss of power in the lower extremities. It is this latter circumstance which explains many of the cases of poisoning in confined places. The workman feels that he is being poisoned, but in attempting, as in a coal-mine, to make his way out into purer air his limbs simply refuse to carry him, and he falls down in a state of insensibility, poisoned by the gas. Death under these circumstances is painless. When acute poisoning by sulphuretted hydrogen, for example, occurs screaming is heard, as in the case of the men working at Hebburn-on-Tyne, to which in another part of this book I have drawn attention. I have not seen mention made of screaming in connection with carbon monoxide poisoning. It occurred in a young dog which had breathed for only a few minutes a high percentage of carbon monoxide gas in atmospheric air. The animal at first showed a little foam on its mouth and then uttered two screams. It was at once taken out of the chamber in a state of unconsciousness. There were slight rigidity of the neck, spasmodic twitching now and then of the hind limbs, and irregular long-drawn breaths. By degrees the breathing became regular, and after ten minutes' exposure in the fresh air the animal, which seemed intoxicated, tried to raise itself. It was weak in the hind limbs and rocked somewhat when attempting to walk. Five minutes later it was able to walk without much staggering. Within an hour after the development of symptoms the animal was running about as if nothing had happened, and shortly afterwards no trace of carbon monoxide was, on spectroscopic examination, found in the blood.

Many of the deaths that occur in a coal-mine after a fire or an explosion are due to carbon monoxide poisoning. It is not a normal constituent of what is ordinarily spoken of as mine gas, but it is a product of the incomplete combustion of coal; it is found in the gases from underground fires and smoke, and "its percentage increases in proportion as the amount of fresh air supplied to the fire decreases. It also forms a constituent of the after-damp produced by an explosion of fire-damp when the percentage of methane exceeds 9·5, because then the proportion of air no longer

suffices for the complete combustion of the methane" (Otto Brunck). Fortunately very small quantities of carbon monoxide do not cause *immediate* poisoning. Miners who have had experience of the gas and of the headache caused by breathing it can, if their limbs will carry them, usually make their way out of the place where the gas is present.

Symptomatology of Carbon Monoxide Poisoning

Giddiness, headache, throbbing of the temples, and ringing in the ears, accompanied by a sense of tiredness, are the symptoms usually experienced by persons who have been exposed to carbon monoxide gas. In severe cases there may be convulsions and loss of consciousness. When the gas enters a bedroom and is inhaled by persons who are asleep, the sleep only becomes deeper; a profound narcosis is developed from which, in many instances, there is no awaking. Should perchance the accident be discovered early, and the persons treated, there are occasionally observed on recovery inability to swallow and muscular tremor. The patient awakes as if from deep sleep; he is dazed for a time and does not recognise his surroundings. He may bring up a little blood-stained mucus from his bronchial tubes. One of the most important after-effects is an alteration or a loss of speech.

Pathology of Carbon Monoxide Poisoning

When death has occurred the face of the cadaver may be pale, livid, or rosy-looking as in health. The face wears a calm expression, showing that no suffering had been experienced. The pupils are dilated. If the body is examined shortly after death, the blood has a beautiful cherry-red colour. Small hæmorrhages may be found in the skin, muscles, lungs, brain, and mucous membrane of the stomach. On spectroscopic examination the blood exhibits two distinct bands between D and E, the yellow and the green lines, similar but not identical to those given by oxyhæmoglobin, the normal colouring matter of the blood. The blood in

carbon monoxide poisoning differs from that in health in so far as it cannot be reduced by such a reagent as ammonium sulphide or Stokes' fluid,[1] and it is upon this circumstance that the spectroscopic test of blood in carbon monoxide rests. The gas forms such a stable compound with the colouring matter of the red corpuscles of the blood that it is difficult to subtract the oxygen from it, hence the occurrence of death by asphyxia in these cases. Although there is neither immediate irritation of the lungs caused by the inhalation of carbon monoxide nor marked difficulty of breathing, yet a few days after an apparent recovery death may come preceded by signs of acute congestion of the lungs. At the time the tendency, rather, is for the higher cerebral centres to become benumbed and for sleep to follow. On microscopical examination of the brain and medulla in fatal cases minute hæmorrhages are frequently found.

Can Carbon Monoxide Penetrate into the Blood of a Cadaver?

An interesting paper has been published by Strassman and Schultz,[2] raising the questions as to whether the detection of carbon monoxide in the blood proves unmistakably that poisoning by the gas had occurred, or whether death might not have been due to other causes, and that, since the corpse had been placed in an atmosphere containing carbon monoxide, there had not been absorbed a sufficient quantity of the gas to complicate the diagnosis of suicidal or accidental poisoning or death from some other cause. When carbon monoxide is found in the blood the natural inference is that it was inhaled into the lungs during life and in this way entered the circulation. In 1902 Wachholz and Lenberger immersed the bodies of stillborn children in an atmosphere of pure carbon monoxide gas, and in half an hour the deep livid patches observed in the skin of the cadavera had become of a red rose colour, and in the blood the presence of carbon

[1] Stokes' fluid must be freshly prepared when required. It is a solution of ferrous sulphate to which a little tartaric acid is added and then ammonia till the reaction is alkaline.

[2] *Berlin. Klin. Wochens.*, 1904, No. 48.

monoxide was determined by the spectroscope—not only then, but as late as seven days afterwards, in the blood removed from the heart. The longer the time that had elapsed between death and placing the cadaver in the gas the less likely was carbon monoxide to be absorbed. Strassman and Schultz are of the opinion that carbon monoxide can penetrate into the blood of a dead person through the skin and external coverings, and that the amount of carbon monoxide in the superficial and more exposed blood and tissues is always greater than that found in the deeper and more central parts.

It is certainly desirable that an answer should be returned to the question as to whether when carbon monoxide is present in the blood of a dead person the gas has penetrated during life or after death. Mirto maintains that in the diffusion of the gas post mortem there is a distinct difference between the anterior portion of the liver, which is rich in carbon monoxide, and the posterior portion, which is of a deeper colour and contains less of the gas. It is stated that this difference is not observed when death has come by poisoning. The blood in the deeper parts of the body contains less carbon monoxide than the vessels at the periphery. Strassman and Schultz found in their experiments upon the corpses of old men that there was no part of the body, practically speaking, into which carbon monoxide did not penetrate, provided there was a sufficient length of exposure to the gas. These observers, too, also noticed the difference between the anterior and posterior portions of the liver to which Mirto had drawn attention, also that in cutting through the tissues the blood nearest the skin always contained the greater amount of carbon monoxide. Such a difference would not occur in a case of poisoning by inhalation of carbon monoxide, since the blood would be equally affected all through the body. The weak point in Strassman and Schultz's experiments is that they do not state what the quantity of carbon monoxide found in the blood was. The importance of this remark is at once apparent when it is known that very minute quantities of carbon monoxide may be present in the blood in normal conditions. The possi-

bility of the diffusion of carbon monoxide into the blood and tissues of a corpse is a matter of great importance from a medico-legal point of view, as the following case shows. In Berlin (Feb., 1904) a woman was found dead in her room with one end of an indiarubber pipe in her mouth and the other attached to a gas pipe, the valve of which was open. The room smelt strongly of coal-gas. Everything seemed to favour the theory that death was suicidal, but at the last moment the father of the dead person intervened and asked for a delay in the interment, as he believed an operation for the induction of abortion had taken place at the instigation of the husband, and that in order to raise the question of suicide the tube had, in order to mislead, been placed in the woman's mouth. An inquiry was ordered, and Strassman and Schultz found that no abortion had taken place, and that there were all the typical signs of poisoning by carbon monoxide on the lines stated in the earlier paragraphs of this article.

The bodies of persons poisoned by carbon monoxide retain their colour and frequently resist decomposition longer than under ordinary circumstances. This has been observed in some coal mining disasters, so that when the dead bodies are brought to the surface the comrades of the dead men, under the impression that death had recently taken place, are not slow to state that the men might have been saved had the rescue work been more timely. Knowledge of the preservative power of carbon monoxide upon the tissues is taken advantage of by butchers abroad to preserve meat by killing the animal by means of carbon monoxide, or after destroying the animal by cutting up the flesh and exposing it to an atmosphere containing carbon monoxide and sulphuric acid vapour ("Les Empoisonnements," Brouardel, p. 283). The meat thus treated does not putrefy, but it undergoes a peculiar decomposition and becomes black and unwholesome. All such methods of treating butcher meat are to be deplored and should be interdicted.

Can living bodies become accustomed to carbon monoxide? This is a subject which Nasmith and Graham[1]

[1] The *Journal of Physiology*, December 29, 1906, vol. xxxv., Nos. 1 and 2.

have tried to solve by means of experiments. Carbon monoxide, as already stated, causes death by destroying the oxygen-carrying power of the blood. Nasmith and Graham allowed guinea-pigs to inhale carbon monoxide until there occurred a 25 per cent. saturation of the colouring matter of their blood with the gas. The animals received daily for several weeks carbon monoxide. None of the animals decreased in weight—on the contrary, most of them gained; and although they were living with 25 per cent. of their hæmoglobin saturated with carbon monoxide they were just as happy and active as those living in ordinary atmospheric air. As these animals were living with only three-quarters of their hæmoglobin available for oxygen-carrying purposes, it was thought they would suffer in health and that anæmia would follow; but instead of this occurring, the red blood cells increased in number, just as in people who live at very high altitudes, and as if a proliferation of new cells had taken place to compensate for the degeneration of some of the red corpuscles. "With 25 per cent. of its blood rendered useless for oxygen-carrying purposes by its union with carbon monoxide the guinea-pig is capable of compensating and will manufacture new red blood corpuscles until it has reached a total of about 8,000,000 with a corresponding hæmoglobin of 105 per cent." The normal number of red blood cells in the peripheral circulation of guinea-pigs is about 6,000,000 per c.mm. of blood, with 88 per cent. hæmoglobin. The animal with true compensation has still three-fourths of its blood corpuscles and three-fourths of its hæmoglobin available for carrying oxygen. To counteract the effect of carbon monoxide a guinea-pig will manufacture 2,000,000 additional blood corpuscles per c.mm. in from three to four weeks, and this increase continues for several weeks after the animal is placed in the open air. Nasmith and Graham carried their experiments further so as to produce 35 and 45 per cent. saturation of the hæmoglobin. "The effect of depriving an animal of the use of part of its hæmoglobin by allowing it to unite with CO is also in many respects similar to depriving it of part of its blood by bleeding." We have seen that the effect of chronic CO

poisoning is similar to that which occurs at high altitudes The similarity is explained by the lack of oxygen being the chief cause of the changes in the blood. When a normal animal was put in an atmosphere sufficient to cause 45 per cent. hæmoglobin saturation it would die in three to four days, while the acclimatised animals remained in good health. In addition to the red the white corpuscles of the blood are increased as well. There is therefore a leucocytosis called forth in the guinea-pig by saturating the blood with the gas. Lack of oxygen produces an auto-intoxication. Carbon monoxide poisoning is nothing else than a toxæmia caused by lack of oxygen. When the colouring matter of the blood is saturated with CO it cannot take up oxygen. In proportion as CO-hæmoglobin is formed so does the blood lose its power of giving up oxygen to the tissues and death therefore ensues. The CO tends to drive out the oxygen from the hæmoglobin and the "final result is an expression of the balance struck between the two conflicting processes." Haldane has shown that when a person remains exposed to a moderate percentage of CO the blood ceases after a time to take up more CO. In the case of the living body it is roughly estimated that "with about ·08 per cent. of CO in the air the hæmoglobin will finally become about half saturated with CO while with ·04 per cent. it will become a third saturated, and with ·16 per cent. two-thirds saturated."[1] Men, like animals, can within limits become acclimatised to CO; and since after a time the blood ceases to take up more CO, it is a question whether men who in their occupation might unexpectedly be called upon to inhale CO should not train themselves to this acclimatisation and bring about that compensation in the blood which we have seen occurs in the guinea-pig. Its effects are the same as living at high altitudes and it does not appear to be attended by any inconvenience. By gradual habituation I have been able to expose dogs to 0·8 per cent. of CO in compressed air for several hours without any bad effects. Probably man could be similarly trained.

[1] "The Investigation of Mine Air," Haldane, p. 145.

Ferro-Silicon

Owing to the death of four persons on a Swedish ship which had been carrying a cargo of ferro-silicon, attention has been drawn by Professor Cronquist to the dangers incidental to the transport of this material. The inquiry showed that poisonous gases are given off by ferro-silicon. During the last few years high-grade ferro-silicon has been produced on a large scale. While in ordinary pig-iron there may be only 2 to 3 per cent. of silicon, in the softer forms of pig-iron there may be as much as 15 per cent. of this material. The presence of silicon tends to reduce the amount of carbon that molten iron can absorb, and to favour the decomposition of any combination which carbon may have effected with iron. In iron ore and quartz there is frequently present a large amount of phosphate which in presence of carbon and a high temperature forms phosphide, *e.g.*, calcium phosphide if calcium is present. If arsenic is also contained in the ore, calcium arsenide might in addition be formed. When ferro-silicon is brought into contact with moisture phosphuretted and arseniuretted hydrogen gases are evolved, both of which are powerful poisons and capable of causing serious symptoms when inhaled. In addition to these poisonous gases, explosions have occurred on board ship the cause of which has not yet been absolutely determined. The dangers incidental to the transport of ferro-silicon are not alone to the persons on the ship, but also to the dock labourers employed in unloading the vessel. Since moisture is the cause of poisoning, owing to the liberation of gases, the greatest care should be exercised so as to prevent the entrance of moisture into the receptacles which contain ferro-silicon.

Illuminating Gas: Water Gas

The risks to life and danger to health from coal gas as an illuminant, also from water gas, depend less upon their manufacture than upon the uses to which these gases are put. Although composed mainly of hydrogen and car-

buretted hydrogen, coal-gas contains as much as 7 to 10 per cent. of carbon monoxide. It is to this ingredient that the illuminant owes its poisonous character. Owing to its disagreeable odour coal-gas can be readily detected, but should it escape from a pipe outside a house or factory and make its way into a living-room or into a workroom, the gas in passing through the soil loses its odour but still retains the poisonous carbon monoxide. People may thus unknowingly be breathing a poisoned atmosphere. When a fracture of a large gaspipe in a roadway has occurred and coal-gas has been escaping for some time, the soil for a considerable distance around may become so impregnated with the gas that, apart from the risk of explosion through men working at the spot with naked lights, the labourers who overturn the soil may be so overcome by the gas that they become unconscious, or they experience severe headache and suffer from vomiting and giddiness so that they are obliged to retire and seek purer air. I have known workmen who had been thus employed suffer in their nervous system for weeks after exposure to the gas, and in one instance I attributed a temporary glycosuria in a workman to this cause. Eleven parts of coal-gas per 100 of ordinary air form an explosive mixture. The mixture is still explosive up to 30 per cent., but ceases to be so after 60 per cent.

Water gas, which is obtained by passing steam over red-hot coke, is occasionally added to ordinary coal gas to improve its illuminating properties, and since carbon monoxide is frequently present in water gas to the extent of 30 per cent., this addition of carburetted water gas increases considerably the dangers of the ordinary illuminant. Water gas, although much more dangerous, has not the disagreeable odour of ordinary coal gas. Its escape, therefore, into a living-room or factory is less likely to be perceived. In a memorandum issued by the Chief Inspector of Factories, dated September, 1904, which deals with the use of water gas and other gases in factories, attention is directed to the manufacture and distribution for heating and lighting purposes of any poisonous gas that does not contain a distinct and pungent smell. It is recommended that in the

manufacture of Mond gas, not only should the quantity of carbon monoxide in the gas be lim ted to 14 per cent., but that the gas should be strongly scented, so that its presence may be readily detected. The importance of this recommendation is apparent when it is stated that between the years 1899 and 1903 there were reported to the Home Office 51 cases of poisoning from carbon monoxide gas (including 17 deaths) in manufacturing premises traceable to leakages from pipes conveying gas, and the cleaning of tanks or flues before sufficient time had been allowed for the gas to become dispersed. It is a regulation of the Home Office that printed bills, calling the attention of the workpeople to the deadly nature of the gas and the best means of rendering first aid, shall be posted on the walls, also that persons with a diseased heart or lungs should not be allowed to be in charge of an engine worked by gas, that the valves and connections of engines should be frequently examined for leakages, and that all flues should be well flushed out by fresh air before the men enter them. Men employed in factories should have a training in ambulance work, so that should an occasion arise when some of their comrades have become overpowered by the gas, they may at once be capable of resorting to artificial respiration and of following this up with oxygen inhalation from cylinders of compressed oxygen, which ought always to be at hand.

I have alluded to some of the permanent effects produced upon the central nervous system by the inhalation of coal gas. It is not so widely known as it ought to be that peculiar mental conditions may be a consequence of coal-gas asphyxiation. Dr. Sanger Brown, of Chicago,[1] draws attention to this subject. The patient, a male, had been found in a sitting posture, leaning against a wall near a gas stove, from which gas was freely escaping. He was unconscious, but by means of artificial respiration and inhalation of oxygen he regained consciousness three days afterwards, and in three weeks he was able to be up and about. His pulse remained high—140 per minute—and there was difficulty of

[1] *Journal of the American Medical Association,* Chicago, April 28, 1906.

breathing on the slightest exertion. The patient's expression was dull and stolid. The red blood cells numbered 5,224,000 per c.mm., and the hæmoglobin, or colouring matter of the blood, was 80 per cent. The time, from thirty-six to forty-eight hours, before he was discovered was a complete blank to him. Memory for recent events was practically annihilated, although he could repeat incidents of his childhood well and discuss with friends events immediately previous to his asphyxiation. He would read the newspaper, but could not discuss current topics. The mental condition never having improved, he died suddenly, eight months after exposure to the gas. At the autopsy no gross changes were found in the brain or spinal cord, nor was there anything present in the other organs beyond slight dilatation of the heart to explain the sudden death. It is more than probable that some physical change had occurred in the brain cells of this patient, whereby they were no longer able to retain new impressions in the same way as previous to the accident. In a similar manner, in all probability, had the nerve cells which control the beat of the heart become affected.

Greidenberg[1] reports three cases, one of which terminated fatally. In the other two patients, a male and female, recovery was slow. There were loss of memory, interference with the power of speech, incontinence of urine and fæces in the male, and subsequently dementia. Other observers have reported cases in which, after recovery from the acute symptoms, there were headache, pains in the limbs, weakness of memory, staggering gait, incontinence of urine, exaggerated knee jerks, tremor of muscles, and death from broncho-pneumonia. In the nervous system there have been found small hæmorrhages in the brain and spinal cord, patchy softening of the spinal cord, blocking of the small blood-vessels in the optic thalamus, fatty degeneration of the endothelial lining of the small blood-vessels of the central nervous system, chromolytic and atrophic changes in the large motor nerve cells, and thickening of the pia mater covering the brain.

[1] "Ueber Psychosen n. Kohlenoxydgas," Vratsch (Russian), 1898.

Nickel Carbonyl: $Ni(CO)_4$

In the manufacture of nickel carbonyl from nickel copper oxide workmen have died in such a rapid manner and under such unexpected circumstances that the Home Office and factory owners felt themselves called upon to make a careful inquiry into all the attendant circumstances. Nickel carbonyl is made in air-tight closed iron chambers. The deaths that occurred were in some instances almost instantaneous, while in others the men died a few days afterwards from inflammation of the lungs. Nickel carbonyl is a very volatile liquid: it boils at 43° C. (109·4° F.). It is obtained from finely divided nickel oxide by first passing hydrogen gas over it. After the water has been removed from the nickel compound, carbon monoxide is brought into contact with the residue; the resulting product is nickel carbonyl.

In the case of one man who died after three days' illness the lungs were found to be œdematous and intensely congested; in another the lungs were inflamed and consolidated as in pneumonia. In the minor forms of poisoning, the men complain of giddiness, difficulty of breathing, vomiting, and unsteadiness in their gait. Opinions are divided as to the cause of sudden death and the ill-health of the workmen, but as there have usually been found small quantities of carbon monoxide gas in the immediate vicinity of where the men had been working, due to an accidental escape of the gas from a leak in the machinery, the symptoms have been regarded as the result of CO poisoning. In a nickel carbonyl worker who died eight days after the commencement of his illness, numerous hæmorrhages were found in the brain and cerebellum, and the nerve cells of the respiratory nucleus in the medulla oblongata showed distinct chromolytic changes. A rabbit which had breathed on two occasions an atmosphere impregnated with the gas given off by 10–15 drops of nickel carbonyl, and which seemed well on removal from the bell jar, was found dead in its hutch a few days afterwards. I sent the brain to Dr. Mott, Laboratory of the Metropolitan Asylums Board, to whom and to his committee I am indebted for a microscopical examination of the same.

Numerous small hæmorrhages were found in the brain and medulla, with acute chromolytic changes of the cells in the medulla oblongata.[1] The lesions found in the body after death from nickel carbonyl poisoning are the same as those found in carbon monoxide poisoning, and as 100 cc. of nickel carbonyl give off 7·3 litres of carbon monoxide gas, this circumstance and the fact that in the case of nickel carbonyl workers who have become ill there have always been found small quantities of CO in the factory close to where the men had been working, at first sight suggest that the cause of poisoning in these cases is carbon monoxide. It is doubtful as to whether after all CO is the toxic agent in $Ni(CO)_4$ poisoning. Langlois found on shaking up blood with $Ni(CO)_4$ that the oxygen of the hæmoglobin was replaced by nickel carbonyl, and Vahleen showed that when circulating in the blood vessels $Ni(CO)_4$ split up into CO and nickel, and he concluded that Ni was the cause of death. H. W. Armit[2] after a series of carefully conducted experiments is also of opinion that the poisonous effects of $Ni(CO)_4$ are due to nickel and not carbon monoxide.

Ferri Carbonyl,

or iron carbonyl, a light sherry-coloured liquid, is, like nickel carbonyl, extremely volatile and equally poisonous. A rabbit exposed for fifteen minutes to the vapour given off by ten drops of the fluid, although at the time apparently nothing the worse for the inhalation, was found dead in its hutch on the following day. The lungs showed intense congestion, with rupture of several of the pulmonary capillaries and escape of blood into the air-cells.

Sulphuretted Hydrogen Gas (H_2S)

This gas when breathed is extremely destructive to animal life. It causes death almost instantaneously if inhaled in large quantities. In the *Lancet*, January 24, 1903,

[1] See my *Harben Lectures*, Royal Institute Public Health, 1905; also *Archives of Neurology*, vol. iii., 1907, p. 258, paper by Dr. F. W. Mott.
[2] *Journal of Hygiene*, July, 1907.

I reported the death of four workmen caused by the inhalation of H_2S. Upon two of the bodies I made a post-mortem examination. The findings at the autopsy were, practically speaking, nil. Beyond a dark and fluid condition of the blood and slight œdema of the lungs, nothing distinctive was found. The men had been employed in making excavations for a dock on the banks of the River Tyne, close to some old refuse from a chemical works, and from this refuse there was a constant trickling of water rich in H_2S. The water had made its way into the iron cylinder in which the men were working. One hundred volumes of the water on being boiled gave off 12·2 volumes of H_2S.

Three of the men lost their lives in an incredibly short time. One of the workmen had got into the iron cylinder, and shortly afterwards, a cry having been heard, a comrade ran to his rescue, and after entering the open caisson he too gave a cry. This brought a third workman to the cylinder, and on his attempting to reach the men he too was overpowered by the gas, and fell dead upon the lifeless bodies of his mates.

Struck by the rapid death of these men by inhaling H_2S gas, I determined to ascertain in what proportion the presence of sulphuretted hydrogen in atmospheric air became poisonous. In submitting a healthy dog to an atmosphere containing 0·02 per cent. of H_2S, no effect followed, nor did anything happen until the quantity of H_2S rose to 0·15 per cent., when the animal suddenly became rigid and fell apparently lifeless, its breathing having ceased. On removing the animal, a feeble beat of the heart could now and then be heard through the stethoscope. By means of artificial respiration the animal in 2½ minutes was quite itself again. The action of H_2S is extremely rapid. A few seconds after exposure to an atmosphere containing even a small percentage of H_2S, it is noticed both in men and animals that the respiration becomes somewhat gasping, and almost immediately afterwards, without further warning than the utterance of a cry, the individual falls down dead in a state of extreme rigidity or in a condition of suspended respiration.

Sulphuretted hydrogen gas causes death by its action upon the respiratory centre. There is no warning; death is sudden and painless. Occasionally a scream is uttered, but by the time the poisoned workman is reached death has taken place, or the breathing has ceased, and only a faint and intermittent beat of the heart can be heard, for it cannot always be felt. After death no characteristic lesion is found in the body to explain the fatal result from H_2S. Along with Dr. R. A. Bolan I exposed blood serum to the vapour of H_2S, and we found that the colouring matter, or hæmoglobin, was slowly converted into methæmoglobin, but to obtain this there is required an exposure of several minutes. Death takes place with such rapidity in H_2S gas poisoning that to this circumstance must be attributed the absence of methæmoglobin from the blood of men who have been suddenly overpowered by the gas.

H_2S is the cause of the sudden death of workmen employed in the sewers of large cities. The danger is most likely to occur when the sewers have become blocked. The presence of 0·2 to 0·4 per cent. of H_2S in the air is extremely dangerous to men working in sewers. Other poisonous gases than H_2S are frequently met with in sewers, such as carbon monoxide from the escape of coal-gas, carbonic acid, ammonium sulphide, &c.

The rapidly fatal action of H_2S is due to the effects of the gas either upon the respiratory centre or upon the terminal endings of the pneumogastric nerves in the lungs. Liebeg thought that poisoning by H_2S was due to the formation of sulphide of iron in the blood by the abstraction of iron from the colouring matter of the red corpuscles, but if this takes place at all it can only be in those extremely slow forms of poisoning where death comes by coma, for death, as a rule, comes too suddenly for such a possibility to occur.

Since H_2S is one of the products formed during the putrefaction of organic matter containing sulphur, the gas is found in privies, the mud of marshes, and in collections of filth manure. There are only a few industrial undertakings in which H_2S may be met with, such as chemical and gas works, the black bronzing of metals by means of sulphide of arsenic,

the cleaning out of boilers, in certain processes of soap-making where large quantities of fat are decomposed, and in the preparation of Prussian blue during the decomposition of ferro-cyanide of potassium by sulphate of iron.

The symptoms met with in the minor forms of industrial sulphuretted hydrogen gas poisoning are nausea, vertigo, headache, and general malaise, all of which soon disappear if the workman goes into the open air. In poisoning by H_2S the workman should be brought at once into the fresh air and artificial respiration immediately resorted to, and continued until perhaps a cylinder of compressed oxygen can be obtained.

Bisulphide of Carbon (CS_2)

This colourless volatile liquid with a disagreeable and repellent odour is used in the manufacture of waterproof goods and in the vulcanisation of indiarubber, owing to the rapidity with which it parts with its sulphur. It is an active and penetrating solvent. It is the vulcanisation, or "curing," of indiarubber goods that is the dangerous process in an indiarubber works. Vulcanisation of indiarubber goods enables them to withstand alterations of temperature and exposure to the weather. Owing to the inflammability of CS_2, the work has to be carried on in rooms in which there are no fires and no naked lights.

The vapour given off by CS_2 has not only a most unpleasant odour, it is dangerous when inhaled. It causes headache, vomiting, and vertigo. These symptoms, if only slight, will disappear if the worker goes into the fresh air. In the deeper forms of poisoning more serious symptoms are observed, *e.g.*, staggering when walking as if the individual were intoxicated, a sense of extreme tiredness, and loss of appetite. When acting as medical expert on the Dangerous Trades Committee of the Home Office, I visited several of the large indiarubber manufactories of England, and found that there had been a considerable amount of sickness and ill-health among the men and women employed in those departments where CS_2 had been made use of

Some of the men whom I saw had been off work for months, and were just recovering from paralysis of the arms and legs due to peripheral neuritis. On young women whose work consisted in dipping such small goods as children's balloons, tobacco pouches, toys, &c., into a bath of bisulphide of carbon the vapour had peculiar effects. Occasionally on their way home at nights from the factory the girls would stagger and fall, and on reaching home would sit down by the fire and fall asleep without touching food. Next day they would feel shaky and tremulous, like men after a debauch, and they would only recover their steadiness after they had again inhaled for a little the vapour from the carbon bisulphide. In other instances the CS_2 would cause acute hysterical symptoms. A worker would become talkative, irritable, excited, and the subject of causeless outbursts of laughter. Acute delirium may occur, attended with delusions. In the more chronic form of poisoning there have been observed weakening of the memory, difficulty of speech, loss of muscular power and of sensation in the arms and legs. Women, if pregnant, frequently miscarry. Occasionally there occurs amblyopia, or loss of vision.

G. Hauft,[1] having met with two cases of accidental poisoning by carbon bisulphide in men, tried the effects of the vapour upon animals. There were the usual symptoms of excitation followed by paralysis, and at the autopsies the liver cells were found sometimes healthy, at other times diseased, the kidneys the seat of an interstitial nephritis, and the lungs the seat of a pneumonia. The central nervous system failed to show any naked-eye appearances to explain the progressive paralysis, which, commencing in the extremities, subsequently involved the muscles of respiration, and finally the heart. There is a general opinion that CS_2 converts the colouring matter of the blood into hæmoglobin, but, on the contrary, A. Chassevant maintains that it has the power of transforming methæmoglobin into hæmoglobin.

Improved ventilation of the workrooms and the adoption of means to draw the vapours downwards and away from the workpeople have done much to diminish the number of

[1] *Archives Internat. de Pharmacodynamie*, 1903, t. xi. p. 155.

cases of bisulphide of carbon poisoning in indiarubber works; but as CS_2 is a dangerous and a subtle poison the hours of work should not be too long at a stretch, and it would be well if employers could alternate from time to time the occupation of the workers.

Acetylene Gas

Acetylene gas is formed when calcium carbide (CaC_2) is brought into contact with water. The gas has illuminating properties superior to those of ordinary gas, and as it can be readily prepared it has come to be sought after as an illuminant for country houses. When purified from calcium sulphide and phosphate the ethereal odour of the gas is not unpleasant. Small quantities of acetylene can be inhaled without any bad effects. When the gas is present in the atmosphere of a room to the extent of 40 per cent. by volume, it is capable of causing death, but when inhaled in the open air it produces little harm, since the poisonous action of acetylene is feeble so long as the blood is at the same time supplied with air containing a proper amount of oxygen. Brociner[1] found that 100 volumes of blood dissolved 80 volumes of acetylene. The blood showed no characteristic spectrum, and, like normal blood, it was readily reduced by ammonium sulphide. Professor Mosso, of Turin, and his assistant Ottolenghi in their experiments found that acetylene was toxic to dogs and guinea-pigs, and that air mixed with 20 per cent. proved fatal within half an hour, but that when the symptoms developed the animal would recover if taken into the open air. In my own experiments upon rabbits I found that so long as ordinary atmospheric air was freely supplied along with acetylene no symptoms developed, but when ordinary air was excluded or a very high percentage of acetylene was present, symptoms gradually developed.[2] Symptoms of poisoning by acetylene are more slowly induced than in ordinary coal-gas poisoning. An animal on becoming intoxicated would fall on its side, ap-

[1] *Boston Med. and Surg. Journal,* July 30, 1896.
[2] *British Medical Journal,* April 23, 1898.

parently in a profound sleep which would pass into coma, but even in this condition a few breaths of fresh air were sufficient to restore it. If the inhalation of acetylene gas were pushed signs of asphyxia would show themselves, and the animal would become at first temporarily cyanosed and subsequently pale. In the deeper stages of acetylene poisoning the blood-vessels are extremely contracted, so that it is difficult to obtain a few drops of blood from them for examination. Once the stage of asphyxia has been reached recovery is more difficult, and yet the blood on spectroscopic examination shows the two well-marked and characteristic bands of oxyhæmoglobin and on the addition of ammonium sulphide and heat is readily reduced. Instead of entering, like carbon monoxide, into chemical combination with the colouring matter of the red corpuscles of the blood, acetylene is probably dissolved in the liquid part of the blood, hence the fact of its being less harmful than coal-gas, and of its being so much less poisonous than water-gas.

When persons are overcome by acetylene gas they should be taken at once into the open air and artificial respiration resorted to if necessary. Oxygen should be administered if the patient is recovering slowly, the limbs should be well rubbed and the extremities kept warm. A hypodermic injection of a minute dose of strychnine may be necessary, or an injection of strong hot coffee by the rectum.

Quickly drying Spirit or Inflammable Paints

Several cases have been reported of men becoming unconscious when working with quickly drying paints, also of men becoming seriously burned as the result of the accidental firing of the vapour given off by the paints. The introduction of rapidly drying or spirit paints is of recent date and is an illustration of the undue haste and hurry of modern times. When a ship puts into port for a few days the vessel can be docked and painted inside and outside to the extent required and be able to leave the dock again in less than two days owing to the use of rapidly drying paints. Half an hour after the application of one

coat of paint another covering can be made. To the owners of the ship time is money. The danger arises when the workmen have to cover in a short time an extensive surface with the paint, and especially in confined spaces.

The colours which form the bases of the paints, instead of being ground with oil, are mixed with methylated or petroleum spirit or with benzine, and while it is the spirit which confers upon the paints their quickly drying properties, it at the same time renders them extremely dangerous to the workmen, both by inhalation of the vapour and its extreme inflammability. Men when painting the interior of a ship's bunks have frequently had to be removed by ropes in a state of unconsciousness. In other instances, when working with naked lights, the vapour from the paints has caught fire and serious injuries have been inflicted. One man whom I saw was extensively burned on the arms, trunk, and face, and he ran the risk of dying from blood-poisoning. When men are working in a confined space they are frequently so overpowered by the spirit vapour that they are unable to extricate themselves from their perilous position. Many of them go to sleep and are found in a state of narcosis or coma. Dangerous as is the use of these rapidly drying paints in the interior of ships, their use externally is equally attended by risk. Sometimes, and without any explanation, unless it be that a soft gust of wind had fanned a naked light or blown a spark, the outside of a ship which men are painting is suddenly and for a moment or two enveloped in flames. After painting bunkers with quickly drying paints the men often complain of headache, dizziness, and unsteadiness in walking. They feel as if they were intoxicated. After vomiting they obtain relief. When men have been hauled out of the bunks in a state of unconsciousness they have generally been found to be pale and to look ill, the breathing has been difficult, and there has occurred bleeding at the nose. By degrees the symptoms improve with the exposure of the men to the fresh air, but for a day or two they remain shaky and nervous. On getting the men home they should be put to bed and given warm drinks.

To prevent such accidents as have been alluded to, naked lights should not be allowed where quickly drying paints are used. The electric light is safer. The greatest ventilation possible should be obtained. No man should work in a ship's bunk for more than an hour or two at a time: he should come out into the fresh air now and then or be visited periodically by a foreman to see that all is right. On undertaking the work for the first time the men ought to have all the dangers pointed out to them, both as regards the risks from inhalation of the vapour and the risks from fire.

Dry Cleaning by Means of Benzine

The dry cleaning of goods by benzine is now an established industry and gives employment to large numbers of people. For cleaning gloves and stained garments nothing is better than benzine. Naphtha is occasionally used for larger clothes. The soiled articles are usually placed first in a revolving drum containing naphtha and soap and subsequently in naphtha alone. The work is carried on in out-buildings in which no naked lights are allowed. Instead of naphtha, benzine may be employed. This may be a petroleum spirit obtained from mineral oil or from coal-tar. The two dangers incurred by the use of these spirit compounds are intoxication of the workers and risks from fire. Before any wearing garments that have been sent to be cleaned are placed in the revolving drum the pockets have to be carefully searched for matches; these and all brass buttons have to be removed, for explosions have occurred owing to friction or electricity or the accidental ignition of the spirit by lucifer matches concealed in the clothing. As there is always a danger from fire the men are not allowed to smoke in the building. Once the garments have been sufficiently rinsed in the hermetically closed revolving benzine cylinder, they are removed and placed in a machine known as a hydro-extractor for the removal of excess of spirit. On being taken out of the hydro-extractor the garments are rinsed in clean spirit, are again placed in the hydro-extractor, removed, dried and finished.

In ways that are quite unaccountable fires often break out in dry cleaning establishments. In one dry cleaning shop which I visited fires and explosions had on eight occasions occurred during fifteen years. These fires often break out on a hot summer sultry evening several hours after the workpeople have left the buildings, a circumstance which has led several persons to believe that benzine has a tendency to undergo spontaneous combustion. At any rate, in most instances the origin of the fire has remained a mystery. Too great care, therefore, cannot be taken in regard to the manipulation and storage of benzine. Materials that have been soaked in it or scrubbed by it should on no account be brought near a naked light, and the waste naphtha and benzine should not be allowed to pass directly into the drains and sewers, for as they give off vapour and as men with naked lights are often obliged to enter sewers, explosions might readily occur.

Benzine vapour affects people differently. Young persons, and especially young females, are more liable to be influenced by it than other people. They become hysterical and excited—they feel as if they were intoxicated. Subsequently they complain of headache and they vomit. On going out of the workroom into the fresh air the symptoms may pass away. Upon some persons benzine produces a heavy, sleepy feeling, a sense of languor and weakness of the limbs. In the severer forms of poisoning by benzine women have suffered from blindness, multiple neuritis attended by loss of power in the limbs, alteration of the gait known as "steppage," accompanied by loss of the knee-jerk, difficulty of speech, and mental depression or hallucinations. Recovery may be incomplete, for memory is often impaired. Naphtha produces similar symptoms but no serious permanent effects. Workers in the naphtha departments of indiarubber works often become anæmic and suffer from headache. Their headache is relieved by going out into the open air. The women become anæmic often through being unable to take food; the taste of the naphtha vapour lingers long in the mouth, so that the workers are unable to eat.

Allusion has been made to the necessity of ventilating very freely all places where benzine and naphtha are employed. No food should be taken into the workroom. Provision should be at hand for extinguishing fires. There ought to be an automatic fire extinguisher on the revolving drums in which the garments are agitated along with the benzine; also plenty of loose sand ought to be lying at hand, and plenty of blankets ready to throw around any person whose clothes have caught fire. The outer garments worn by the workpeople should be made of wool. Where dry cleaning establishments are several storeys high there ought to be fire-escapes in accessible places.

There are not many cases of fatal poisoning by benzine on record, but in a case reported by Santesson of Stockholm the lesions found after death were—fatty degeneration of the heart, liver, kidneys and of the endothelial lining of the small blood-vessels. In "Poisons Industriels," p. 54, mention is made of a patient of Lenoir and Claude. The man, who was a dyer, aged 27, in consequence of inhaling the vapour of benzine died from purpura hæmorrhagica. He had also bleeding from the nose and gums, and hæmorrhages into his pleural cavity. The experiments carried out by MM. A. Chassevant and Marcel Garnier, and reported in *Archiv Internat. de Pharmacodynamie et de Thérapie*, 1905, show what a poisonous liquid benzine is. They injected small quantities into the peritoneal cavity of guinea-pigs. Three to five minutes after an injection of benzine there was general muscular tremor, so that the animal would lie down on its side. The amplitude of the convulsions became greater as time went on, accompanied by a complete loss of the muscular tonus, so that the animal's body could be bent in all directions. This hypotonus did not appear at the same time as the convulsive tremors—generally half an hour afterwards. There was also a marked fall of the temperature of the body. If the dose was sufficiently poisonous to lead to a fatal termination, the symptoms mentioned continued until death, but even with small doses there was always a fall of temperature. With a small toxic dose death came from eight to nine hours after an injection, but if the dose was

large the animal died in less than three hours usually after a severe convulsive seizure and complete hypotonus.

On making a post-mortem examination of animals poisoned by the injection of benzine into the peritoneal cavity there is detected a strong odour of benzine when the abdomen is opened. Occasionally there is a small quantity of a reddish liquid in the peritoneal cavity, the serous membrane of which is frequently congested, and shows numerous small ecchymoses or minute effusions of blood. The abdominal organs are usually of a dark red colour, although the liver here and there shows a few white spots. The mucous membrane of the stomach along the great curvature is found to be the seat of numerous small brown patches and ecchymoses; sometimes there is ulceration. Since the benzine under these circumstances was not swallowed, it is evident that as the minute hæmorrhages in the stomach bear a distinct relation to the course of the arteries, they are due to the elimination of the poison from the blood by the mucous membrane of the stomach. In acute poisoning by benzine the earliest symptoms are on the side of the nervous system, viz., convulsions, loss of muscular tone, and extreme depression of the body temperature. Death may come from the nervous system alone; but, as already stated, if life is spared for a few hours, the gastro-intestinal canal becomes implicated, for the lesions found therein bear strong evidence of an effort on the part of the organism to eliminate the poison by the mucous membrane of this canal.

Petrol

As a consequence of exposure to the vapour given off by petrol, workmen at the end of the day, especially if they have been working in a confined space, often complain of headache, vertigo, nodding of the head, and discomfort in breathing. These symptoms are extremely apt to occur in men employed in the distillation and refinement of petrol. In cleaning out the tubs for holding petrol men have become asphyxiated. Wielczyk states that among the miners employed at the petrol springs in the Carpathian mountains asphyxia is not unknown. Petrol vapour, like that of benzine,

destroys the colouring matter of the blood. To this circumstance may be attributed the anæmia occasionally observed in the workmen.

Owing, among other things, to the prosperity of the motor-car industry, the demand for petrol within recent years has much increased. Special steamers have been built for bringing petrol from Sumatra and other places to this country. Some of these steamers carry enormous quantities of petrol, as much as 12,000 tons. A certain risk attends not so much the filling of the tanks and the transport of the material, as the cleaning out of the tanks after the cargo has been discharged. The petrol is shipped in specially prepared tanks, and care has to be taken that the tanks are well filled. Ventilating shafts run from these tanks to the mast-head of the ships. After the ship has been docked and the petrol removed, men descend to clean the tanks. Peculiar symptoms have developed in the workmen. In the minor forms of petrol poisoning the men have become intoxicated and excited, others have become hysterical; while in the deeper forms of poisoning the men have been so overcome by the vapour that they have passed into a state of coma, in which they would probably have died had they not been hauled on deck and allowed to breathe fresh air. The men become asphyxiated by the vapour, and on recovery often vomit and complain of severe headache. In order to prevent such accidents it is necessary, before allowing men to go into the tanks, to close down all the hatches and to introduce steam into the tanks. By this means the petrol vapour seems to be robbed of its power for harm, so that men can enter and by means of tow clean out the tanks. Owing to the inflammable nature of petrol vapour all fires and naked lights on the ship have to be extinguished during the emptying of the cargo.

Blanket-stoving

Blanket-stoving was not considered to be an unhealthy occupation by a committee appointed by Mr. Asquith, when Home Secretary, nor by Dr. I. A. E. Stuart, of Batley, who has

had a large experience of the workers, since he finds that the mean age at death of the men employed is 64·1 years. The men suffer from an irritating cough, occasionally accompanied by the expectoration of a small quantity of blood, during and after the removal of the blankets that have been exposed to the fumes of brimstone in the stoving-house. Most of this part of the work, the object of which is to bleach the blankets, is carried on in the winter months. During the summer the blankets are dried outside, and as this work necessitates the fixing and stretching of the blankets upon tenter posts it entails considerable physical effort on the part of the workmen. There is a common belief in the district where the work is carried on, that the men who are exposed to the sulphur fumes do not become the subjects of tuberculous lung disease, an opinion which medical experience rather confirms than otherwise. A similar immunity to infectious diseases is also conferred. The men drink beer in large quantities, owing, it is said, to dryness of the mouth and throat, caused by work in the drying-house and the heavy perspiration which this causes. From the nature of their employment, the inhalation of sulphur fumes and alternating exposure to heat and cold, several of the men become the subject of chronic bronchitis and emphysema of the lungs. Although there is a remarkable freedom from tuberculous lung disease, yet phthisis and pneumonia are not unknown among the workmen. Taking the work generally, it cannot be said to shorten life, since the average age at death of blanket-stovers in 64·1. Efficient ventilation and machinery for raising and stretching the blankets upon tenters would help to make the employment even healthier than it is.

CHAPTER III

DISEASES DUE TO WORKING IN CAISSONS AND COMPRESSED AIR

ENGINEERING science has done much for the comfort of man and played no unimportant part in the cause of civilisation. By the extension of railways national barriers have been broken down and physical difficulties overcome that well-nigh seemed insuperable. A century ago, when it was necessary to span a river by a bridge, the sustaining piers in the centre and sides of the river often rested upon huge piles of wood that had been driven into the soil, but in modern days the bed of the river is attacked by engineers in quite a different manner. Men work on the bed of the river and below it in closed iron cylinders, or caissons, into which compressed air is driven by means of powerful machinery, and as excavation proceeds the caisson sinks by its own and superadded weight until solid rock is reached, or a condition of soil is attained capable of sustaining the caisson, which, when filled with concrete, becomes the substructure of the pier of the bridge. Although all the required operations, mining and engineering, are carried out in harmony with physical laws, yet the conditions under which the men work are unnatural, and are therefore attended with considerable risk to the health and life of the workmen, hence the terms "caisson disease," or "compressed-air illness."

A caisson in its simplest form is, when in position, an iron cylinder, somewhat bell-shaped, and open at its lower extremity. Its upper extremity is closed in by an iron roof, but this is really the floor of a smaller superadded chamber, part of the roof of which along with the floor already men-

tioned is movable so as to allow of the passage of the buckets filled with the soil removed by excavation. This upper chamber is known as the "material" chamber. Built on to the outer side of the upper part of the caisson is an iron chamber, entrance into which is guarded by a strong iron door. Leading out of this chamber is a doorway that conducts into the interior of the caisson. This entrance into the caisson is also guarded by a strong iron door. The chamber just described is that through which the men enter and leave the caisson. It is known as the "air-lock." By means of strong iron pipes connected with a compressor engine, atmospheric air is pumped into the caisson, which drives the water out of the caisson and keeps it out, so that men can work inside the iron cylinder on the bed of a river and remove the soil. The workmen enter the caisson through the air-lock. Once in the air-lock the outer door is closed, either by the men themselves or by some one outside. The inner door which leads from this chamber into the interior of the caisson is at this time also closed; it is kept thus by the pressure of the compressed air within the caisson. When the men have got comfortably into the air-lock, compressed air from the caisson is, by means of an air-cock, allowed to escape into the air-lock. The air-cocks which admit the high-pressure air are made purposely small so as to prevent too rapid compression which, if it occurred, might give rise to troublesome symptoms. As soon as the pressure in the air-lock comes to equal that inside the caisson the inner iron door opens, practically speaking, of itself, when the men enter the caisson or working chamber, and by means of an iron ladder descend to the bed of the river. During the short time the men are in the air-lock preparatory to entering the working chamber, they are undergoing what is spoken of as "compression." The stop-cocks are manipulated by trained men inside and outside the air-locks. Men who are undertaking the work for the first time occasionally experience considerable discomfort during the process of compression. As the pressure rises within the air-lock the drum of the ear is forcibly driven in, and some men not only become deaf but experience severe earache, and headache attended by

dizziness. Men who are used to the work obviate all of these by swallowing air and passing it up the Eustachian tube into the middle ear, so that by the presence of this air-pad on the internal side of the drum of the ear the painful depression of the membrana tympani is prevented. In some instances where such preventive measures have not been employed the drum of the ear has ruptured. During compression the blood keeps absorbing the gases of the air until the tension of the gases in the blood becomes equal to that in the compressed air. Once this equilibrium has been attained immunity from immediate troubles is secured. Barring accidents, the men can work in the caisson for hours without experiencing any inconvenience, the amount of work done in a given time being equal to that which the men could do if similarly employed outside a caisson. The opinion has been expressed that the work inside is not so fatiguing. Formerly caissons were illuminated by naked lights, but the smoke from the lamps and the consumption of the oxygen of the air polluted the atmosphere. The electric light has supplanted all other illuminants. When the buckets have been filled with soil they are hauled up to the material chamber, part of the floor of which slides so as to allow them to pass through. The sliding doors are at once closed by the men in the caisson who superintend this transport of the soil. For the next few moments the "material-lock" is a compressed-air chamber. After a brief period of decompression the roof of this chamber is opened by men outside the caisson, when the bucket is lifted by a crane, emptied, and returned, and when the roof again closes compressed air is turned on, the floor slides, and the bucket descends. So perfectly do the movable doors fit and so adaptable are the manipulations, that there is, practically speaking, no escape of the compressed air.

At the close of a shift, or when the men inside the caisson have finished their work for the day, they ascend the ladder, enter the air-lock, and close the door which separates the caisson from the air-lock. As the men are still in compressed air the outer door remains firmly closed. By means of a stop-cock air is allowed to escape into the external atmosphere, and by degrees the pressure in the air-lock falls. When the pressure inside

the air-lock equals that of the external atmosphere the outer door readily opens, and the men emerge enveloped in a thick mist or fog, for during decompression the air in the air-lock becomes extremely cold and saturated with aqueous vapour. It is while the men are coming out of the air-lock, or shortly after having undergone what is known as "decompression," that there occur the dangers to health and risks to life. The caisson just described is such as is used in subaqueous excavations in vertical positions; but large caissons may be employed with two or three shafts, each fitted in its upper extremity as already stated. In making tunnels under a river, or under the streets of a large town, caissons are also employed; these differ slightly in construction from those used on rivers, but the principle is the same.

To enable the men to do their work well when in the caissons pure air, and an abundant supply of it, ought to be pumped in by the compressor engine. There has generally been a considerable amount of sickness among the workmen when the supply of atmospheric air has been insufficient, or when it has been rendered impure by gases given off from the soil the men are excavating. In sinking the foundations for the piers of the King Edward Bridge at Newcastle-upon-Tyne the greatest amount of sickness among the men occurred when they were passing through a layer of soft coal below the bed of the river. Probably small quantities of carbon monoxide gas were given off, or sulphuretted hydrogen, for the men complained of a disagreeable odour. The ventilation of the caissons should be kept free by an excess of air pumped in at the upper extremity of the caisson and allowed to force its way outwards by the lower extremity. The air inside the caisson becomes vitiated by the respiratory products of the men, of whom, according to the size of the working chamber, there may be as many as from three to forty inside. In the large caissons on Tyneside thirty-five men worked at one time. As the men when inside the caisson work hard and consume large quantities of oxygen, the necessity for an abundant supply of air is apparent. At the Blackwall Tunnell, Snell[1] found that while the esti-

[1] "Compressed-air Illness," E. Hugh Snell, M.D.

mated number of cases of illness for 100 days was 80·9 when less than 4,000 cubic feet of fresh air per man per hour were supplied, and 22·5 when the amount was 4,000 to 8,000 cubic feet, the numbers fell to 8·5 when upwards of 8,000 cubic feet of air were supplied. It is Dr. Snell's opinion that the amount of illness varies inversely with the amount of fresh air supplied. Experience to some extent confirms this theory, but the actual part played by carbonic acid gas in the production of caisson disease has yet to be demonstrated. It goes without saying that the health and safety of the workmen are enhanced by the supply of air being abundant and pure. As compressed air is hotter than ordinary atmospheric air, the temperature at which the men are working in the caisson is considerably higher than that of the outside air, consequently a layer of cold water should be kept circulating round the cylinder of the compressor engine to keep the temperature low and the air cool, and only high-flash oils, 500° F. and upwards, should be employed, so as to prevent the possible contamination of the air by the decomposition products of an over-heated oil. The surplus air escapes in tremendous volumes by the cutting edge of the caisson, or that part which rests upon the soil, but should, perchance, the bell-shaped expansion of the caisson settle down upon a bed of clay, and no air escape, as what occurs in what is called a "water-tight" stratum, there would be danger were there no safety-valves present in the upper part of the caisson to act automatically when the pressure rises too high. Safety-valves, too, are provided on the compressor engine, so that the "cut out" acts immediately the pressure has risen too high. There should always be at least duplicate compressor engines. Owing to the large size of the caissons employed by the Cleveland Bridge Company on the river Tyne, their extreme weight, and the possibility as they keep sinking of their tilting over on one side, or of suddenly sinking into the soil and crushing the men between the soil on the one hand and the roof of the working chamber on the other, strong iron girders were built transversely across the interior of the caisson, and the men were never allowed to work underneath a girder. Two such girders spanned the interior of each of

the large caissons on the Tyne and divided it into three chambers. Through a large circular opening in the girders the men could pass from one chamber to another, and in the event of such an accident happening as the sudden tilting of the caisson, the air supply and the ventilation would hardly have suffered. As the caisson sinks it is steadied by a large amount of concrete that surrounds it. Mr. Frank Davis, the manager of the Cleveland Bridge Company's operations on the River Tyne, informs me that some of the caissons when filled with concrete, and that which is superposed, weigh upwards of 10,000 tons. In bridge building the caissons are not removed; they are filled with concrete and become the substructure upon which the masonry is reared. They form the piers of the future bridge. As the men inside the caisson can readily communicate by means of knocks with the men outside, there is no necessity for having telephones inside the working chambers. Fortunately accidents happen but rarely inside the caissons; still it would be well to have inside the caissons a sling or other suitable appliance whereby injured men could be hoisted to the level of the air-lock should the need arise. As the caissons keep sinking owing to the removal of the soil, fresh lengths have to be added to the shafts, but air-locks must be always above high-water level mark. The pressure within the caisson has to be regulated according to the depth at which the men are working and the circumstance as to whether in tidal rivers the water-level mark is high or low.

It requires 1 lb. of air pressure to displace 2 feet 4 inches of water. Ten metres of water are equivalent to one atmosphere of pressure. For every 33 feet of water a pressure of + 15 lbs. to the square inch, or 1 atmosphere, is required to keep the water out of a caisson. Men, if working at a depth of 100 feet, would require a pressure of + 3 atmospheres, or 45 lbs. in the caisson.

Among the earliest cases of "compressed-air illness" to be reported were those of Pol and Watelle in 1854, whose experience was gained while in charge of sixty-four men who were working in caissons at 48 lbs. pressure on the River Loire. The men worked only four-hour shifts, and the time spent in

decompression was half an hour. Forty-seven of the men stood the work well, twenty-five had to be discharged through illness, and two died. The serious cases numbered sixteen, all of which occurred after decompression.

Caissons were first employed in England at Rochester in 1851, by Hughes, during the construction of a bridge over the Medway, and shortly afterwards by Brunel at Chepstow and Saltash. At Saltash one man died shortly after coming out of a caisson in which he had been working at a depth of of 87·5 feet and under a pressure of 40 lbs. At the St. Louis Bridge, on the Mississippi, 600 men were employed in sinking the foundations. Of these 600 men, 119 suffered from caisson disease, 14 of whom died. At the Brooklyn Bridge, New York, there were 110 cases of compressed-air illness, with 3 deaths. The Forth Bridge and the Blackwall Tunnel were the first works using high pressures which were completed without a fatality. No death from caisson disease occurred in the Baker Street and Waterloo Railway tunnel works in London. At the King Edward Bridge, Newcastle-upon-Tyne, one man died from the effects of caisson disease attended by complications.

Symptoms of Compressed-air Illness

The pathological effects of compressed air occur at two different periods, (1) when the men are undergoing pressure, and (2) during or after leaving the pressure. The symptoms in the first instance are mostly mechanical, as, for example, the pains in the ears already referred to and due to the pressure upon the membrana tympani, also pains in the frontal and maxillary sinuses. By inflating the middle ear through the Eustachian tube the men can prevent these unpleasant symptoms. Unless the drum of the ear ruptures and is followed by acute inflammation, the symptoms require no treatment. It is otherwise with those that belong to the second category. These may develop while the men are in the air-lock undergoing decompression. This is a rare event inside the air-lock, but it occurred in one of my own patients, the only case occurring in Newcastle-on-Tyne that proved fatal. In some

instances the men have had to be lifted out of the air-lock in a condition of unconsciousness. These are always serious cases, especially if the coma is attended by convulsions. Usually the symptoms do not show themselves for some time—a few minutes, half an hour, or several hours after the men have come out of the air-lock. In an ordinary way the men complain mostly of severe pains in their muscles and in their joints, which they call "bends." The knee-, elbow-, and hip-joints are, as regards frequency, individually affected in the order mentioned, but they and other joints may be simultaneously affected. Often the pains are excruciating and cause the strongest men to writhe in agony. The earlier the pains develop after the workmen emerge from the air-lock the more severe they are. "Bends" may continue for a few hours or for two or three days. I have frequently grasped the aching limbs of the men suffering from "bends," but neither pressure upon them nor friction of the joints seemed to aggravate the pains. Occasionally the men after decompression bleed at the nose, or they complain of severe abdominal pain and vomiting. In many instances it is only after the men have left their work and are on their way homewards that they are seized with extreme pains, or they become paralysed in their limbs and fall. It is the lower extremities that are paralysed. The loss of power in the legs may come on several hours after decompression, and may be transitory or permanent. This paralysis is accompanied by retention of urine, requiring the use of the catheter. Vertigo is not an uncommon symptom. Under its influence workmen may be seen to stagger and stumble as if intoxicated. One of my patients was the subject of acute delirium for a few days, two others were enfeebled mentally, and for a time were childish and almost imbecile, while several others, again, were nervous and appeared to be the subjects of unaccountable fear. Occasionally there is temporary but partial blindness without opthalmoscopic changes in the retina to explain the loss of vision. Double vision, and loss of hearing with facial paralysis, have occurred. Some of the men become nervous and hysterical. In other instances it is difficult to say whether they are not malingering. In the

minor forms of caisson disease the muscular system and joints are most affected; in the severer forms it is upon the central nervous system that the brunt of the illness mostly falls, the spinal cord more than the brain.

What are the Symptoms due to?

Inside the caissons the men are working under abnormal conditions. The air-pressure is high and the work is hard. There are no signs of illness so long as the men are in the compressed atmosphere if the air is good. It is after the men return from a high to a low pressure that symptoms arise. The length of time spent in the working chamber, the purity of the air, the height of the pressure, and muscular fatigue are predisposing circumstances. Men who are working a four or five hours' shift are more likely to become affected than other men working at the same pressure for only half the time. In this country the men seldom work under pressures higher than 35 lbs. to the square inch; to this must be added the ordinary atmospheric pressure of 15 lbs. Since 1 lb. of air pressure is required to displace 2⅓ feet of water, the pressure just mentioned would correspond to a depth of 70 to 80 feet below high-water level mark if the work was being carried on under a tidal river. The pressure is caused to vary with the rise and fall of the tide. According to the depth at which the men are working, and therefore the pressure, so should be the length of the shift. The higher the pressure the shorter ought to be the shift. It was when the men were digging through a layer of soft coal below the River Tyne that there was experienced an unpleasant odour and there was the greatest amount of sickness, and at the Forth Bridge it was when the men were removing the soft silt on the bed of the river that Dr. Hunter had the largest number of men off ill. Impurity of the air is a factor in causing illness, not necessarily of the typical character of caisson disease, but which places the individual *hors de combat*. It is difficult to estimate the part which excess of carbonic acid, for example,

plays. Snell's observations on this point are perfectly clear. The amount of sickness was found to be proportional to the quantity of carbonic acid in the air. An increase of carbonic acid from ·04 per cent. to 0·1 per cent. at 30 lbs. pressure was always the forerunner of much illness. Dr. F. R. Wainwright, who had medical charge of the men employed at the Baker Street and Waterloo Railway tunnel, found that "from May 23rd to October 4th, with an average of 6,000 cubic feet (of air) to each man per hour, there were 34 cases (of illness), say 8 cases per month. Following this with an average of 1,700 cubic feet to each man per hour, there were 13 cases in a period of 12 days," and the cases occurring during the latter period came on sooner after decompression and were more severe than those that occurred when the ventilation was better. On the River Tyne the amount of fresh air pumped into the caisson was only 1,320 cubic feet per man per hour, and yet there were very few cases of illness. At the Brooklyn Bridge the air in the caissons contained 0·33 per cent. of carbonic acid, but at the Baker Street and Waterloo Railway tunnel it was 0·06 to 0·07 per cent. Even when the men were working at a maximum pressure of 36 lbs. at Brooklyn, Dr. Smith, who was in medical charge, reported 110 cases of compressed-air illness in four months, whereas at Baker Street, with eight-hour shifts, there were only 47 cases in five months. Dr. Smith does not attach much importance to the ventilation, for he remarks that "this amount (0·33 of CO_2) of vitiation was found not to affect the men unfavourably." Snell's and Wainwright's observation, theoretical considerations, and the Brooklyn Bridge statistics, suggest the existence of some relation between volume of air supplied with the quantity of CO_2 contained in it, and the amount of sickness in the men, but precisely what that relation is it is difficult to say. Wild rats which I exposed to 50 lbs. pressure of atmospheric air, containing quantities of CO_2 varying from 0·6 to 1·04 per cent. for seven hours, behaved differently: some experienced little or no inconvenience, while two or three, although on removal from the caisson they were apparently quite well, yet died a day or two afterwards. On examining their lungs microscopically

there were found evidences of patchy congestion with small hæmorrhages, also congestion of the liver. A dog, on the other hand, was on several occasions for seven hours in compressed air which contained 0·3 to 2·16 per cent. of carbonic acid, and under a pressure of 50 lbs. without ill-effects. He kept falling asleep in the caisson, but beyond that nothing was observed.

On the River Tyne the amount of carbonic acid present in one of the caissons on working days varied between 20 and 30 volumes per 10,000, while the ordinary atmospheric air in the neighbourhood of the caisson contained 5 volumes of CO_2 per 10,000: the amount varied between 0·2 and 0·3 per cent., and yet it cannot be said that there were many cases of compressed-air illness, notwithstanding the fact that only 1,320 cubic feet of air per man were being pumped in. On the particular day in which the most serious case of illness occurred in the caisson the amount of carbonic acid was less than usual. There have been several fatal cases of compressed-air illness at the Hudson River Tunnel, New York, but on carefully going into the figures and comparing them with the percentage of carbonic acid in the air of the tunnel, there does not appear to be such a constant relationship between the two as to imply a causal connection. Notwithstanding this it is desirable that the air in the caissons should be kept as pure as possible.

It is interesting to remember that even oxygen, which is of all the gases the most important, from a vital point of view, becomes a poison when breathed in excess and in a compressed form. It produces toxæmia and inflammation of the lungs. Paul Bert, on exposing dogs to high pressures of oxygen and rapidly decompressing them, found that the animals became convulsed and that the amount of carbonic acid in the blood became markedly diminished owing, he presumed, to the excess of oxygen arresting the metabolism of the tissues. Assisted by Dr. Alfred Parkin, I carried out a series of experiments at the Newcastle College of Medicine, with mice. Exposing them to high pressures of oxygen, say 10 atmospheres and upwards, some of them died in convulsions even when brought into ordinary atmospheric air,

while others that came out of the compressed oxygen died a few days afterwards from acute congestion of the lungs. Pneumonia is one of the consequences of breathing oxygen under high pressure. Professor Lorrain Smith, of Owen's College, has suggested that inflammation of the lungs might be the cause of caisson disease, but as some of the worst cases of compressed-air illness on the Tyne occurred when the men were working at rather low atmospheric pressures, and therefore not exposed to high-tension oxygen, and the lesions in caisson disease are more in the nervous system than in the respiratory organs, it does not appear that oxygen tension nor congestion of the lung is the cause of compressed-air illness. Under the atmospheric pressures at which the men are working in the caissons, the oxygen tension is not high enough to cause pulmonary congestion. The convulsions produced in animals by high oxygen tension are in all probability the result of the toxic effect of oxygen upon the central nervous system.

Parkin and I found that mice behaved differently in high pressures of oxygen and compressed air. Exposed to + 10 atmospheres of oxygen, mice in seven or eight minutes became convulsed, but when exposed to even higher atmospheres of compressed air for the same period no convulsions occurred, owing, probably, to the length of time being too short for intoxication to occur from the oxygen in the air. With high oxygen pressures convulsions develop during the period the animal is in the compressed-air chamber: the convulsions are, therefore, in all probability toxic in origin, but with high pressures of atmospheric air symptoms do not arise until the animal has been decompressed, when the more sudden the decompression the greater the tendency for symptoms to develop. The symptoms in the latter instance are due to quite a different cause, viz., frothing of the blood in the small vessels. During the time men are working in compressed air the circulation of the blood is, practically speaking, unaltered. The pulse may be quickened at first, but this is temporary. On the other hand, some of the air the men are breathing is pressed into the blood under the high pressure and is held therein in solution, the solution of

the gases being proportional to the pressure in accordance with Dalton's law. Since nitrogen forms four-fifths of the air we breathe, it is this gas which is found dissolved in the largest quantity in the blood in compressed-air illness. Leonard Hill[1] tells us that on one occasion when a compressed-air chamber suddenly burst, the dog which was the temporary tenant of the chamber was killed, and that the blood removed from the right side of the heart of the animal yielded, on analysis, 15·2 per cent. of carbon dioxide, 82·8 of nitrogen, and 2 per cent. of oxygen. Nitrogen of itself is a harmless gas: 100 cc. of blood under 1 atmosphere of pressure will absorb 1·23 cc. of nitrogen and under 4 atmospheres 4·92 cc. When decompressed from 4 to 1 atmosphere the same blood will give up 3·69 cc. of nitrogen. It is estimated that the whole of the blood in the body of a man weighing 70 kilogrammes would give up 130 cc. of nitrogen, but his tissues and fluids would probably yield ten times more.

When the air in a caisson contains a larger percentage of carbonic acid than usual, there is the danger of a larger amount of carbon dioxide being pressed into the blood under these circumstances. The effect of the sudden decompression of a man who has been exposed to a high atmospheric air-pressure is exactly the same as what occurs when a bottle of soda-water is opened—effervescence occurs: the blood as it escapes from the heart of an animal killed by rapid decompression can be seen frothing. On exposing pithed frogs to high atmospheric pressures and watching through a microscope the circulation in the web of their feet, it was noticed that while for a moment the circulation was quickened, the flow of blood gradually returned to the normal and remained thus, nothing abnormal being detected as regards the calibre of the blood-vessels. When decompression is suddenly induced no immediate change occurs in the circulation. Two or three minutes afterwards, however, the blood stream is observed to become slower and slower, subsequently it oscillates in the vessels—now forwards, now backwards—and then there appears a bubble of air inside one or more of the capillary

[1] *Lancet*, July 1, 1905, p. 4.

blood-vessels. Another bubble or two of air presently appears, and these coalescing fill a considerable part of a capillary. Where in the vessels there was previously blood there is now air, and the circulation in that particular vessel ceases. Occasionally there is a rupture of small blood-vessels, when air and blood escape into the tissues. It is the sudden setting free of the gas previously dissolved in the blood which is the cause of the frothing of the blood seen in an animal that has been killed by rapid decompression, and is the explanation of caisson disease or compressed-air illness in men who have been working at high air pressures and been too rapidly decompressed. The bubbles of air are for the most part nitrogen, simply because nitrogen is the largest constituent of atmospheric air and more of it is absorbed than of the other gases. While possibly carbon dioxide and carbon monoxide may be more dangerous to health when inhaled in the compressed form, and predispose to the development of certain symptoms, yet caisson disease is not so much the result of a toxæmia or poisoning as of the sudden liberation of gas and the presence of air emboli in the blood, rupture of capillary vessels, and the presence of free air and blood in the tissues. The symptoms are largely the result of mechanical causes. Frothing of the blood is the main cause of caisson disease. The longer the workmen are in the caisson and the greater the muscular fatigue, the higher the pressure and the rapidity with which decompression is effected, the more likelihood is there of caisson disease developing. As already stated, the symptoms are met with mostly on the side of the muscular system and the joints ("bends"). As concerning the central nervous system, coma and convulsions point to the brain as being affected, and paralysis of the legs to a lesion of the spinal cord. Of all the cerebro-spinal symptoms paralysis is the most common, owing to the lower portion of the spinal cord being that which is the most frequently affected. Why this particular portion of the spinal cord should be so frequently selected has never been adequately explained. It has been attributed to the length of the small arteries in this part of the nervous system and the comparative absence of external

support to their walls. The following attractive theory has recently been advanced by Dr. H. M. Vernon at a meeting of the Royal Society. In carrying out a series of experiments to determine the solubility of air in various fats, Vernon found that at body temperature the fat of mammals probably dissolves five times as much nitrogen as water or blood plasma. It is known that for caisson work men of spare build bear rapid decompression better than stout men. The spinal cord is rich in fat-like substances (20 per cent.). Vernon suggests that this circumstance may account for the frequency with which spinal cord lesions occur in caisson workers, and if it could be shown that the bulk of the nitrogen is absorbed by the tissues and not by the blood, the view put forward by Vernon would be considerably strengthened. It is said that no actual intercellular or intracellular liberation of air has been definitely proved to occur, but in my experiments upon pithed frogs bubbles of air were frequently seen outside the capillary blood-vessels as well as inside of them, a circumstance which points to the absorption of the dissolved gas and its subsequent liberation in gaseous form by the intercellular liquid or lymph. The presence of gaseous emboli in the blood-vessels is acknowledged to be the main cause of the symptoms of caisson disease, but microscopical examination of sections of liver and brain show that the tissues themselves and the lymph that bathes them had absorbed the gas, judging from the large number of circular spaces created by the bubbling forth of the gas. Vernon is of the opinion that the special liability of fat or adipose tissue to injury on rapid decompression is probably a resultant of two factors—"its greater solvent power and relatively limited blood supply." More gas would be dissolved, which, owing to the scanty supply of blood-vessels, would with difficulty be removed.

It was Paul Bert—a Frenchman—who put the pneumatic theory of caisson disease upon a scientific basis. The bubbles of air usually appear first in the venous side of the circulation. When decompression is carried out slowly, nature provides for the gradual escape through the lungs of the gases that have been dissolved in the blood. This gradual escape

of gas through the lungs is the saviour of the individual. The danger incurred by workmen in passing rapidly from a high to normal atmospheric pressure is that bubbles of air are liberated in the blood-vessels and in the tissues, that the tissues are thereby starved or torn, and as a consequence function is lost. This explains the paralysis of the limbs. It would suggest, too, that if more time were spent over decompression fewer accidents would occur, a view of the relationship which we cannot but support. And yet serious cases of compressed-air illness have occurred when men have not worked under high pressures, say only 12 lbs., and when neither the shifts have been too long nor decompression too rapid. It is these cases that are difficult to explain, and towards the elucidation of which Dr. George W. F. Macnaughton [1] has submitted the theory of frictional electricity as a factor in caisson disease. As the work of a caissonier is hard there is, in consequence of the muscular exertion, a repleted condition of the visceral veins as well as those of the cerebro-spinal axis. When there is added to this circumstance the influence of the two or three extra atmospheres of pressure in which the men are working, the over-distended vessels create a local pressure which interferes with the nutrition of the nerve cells; to this malnutrition the accumulation of the products of metabolism in the perilymph contributes. There is thus induced, according to Macnaughton, a local rise of acidity which is a stimulant to the discharge of energy by those cells. Some writers have attributed the muscular pains and "bends" to the accumulation of carbonic acid and toxins generated during muscular exertion. It is maintained that the caisson atmosphere is charged with electricity carried in by droplets of water-vapour. The man who is working in this atmosphere "accumulates upon the body surface electricity which either by directly permeating the tissue reaches, amongst others, the nerve centres, or by acting upon the peripheral nerve filaments or muscle end-plates stimulates these centres from the afferent side. Although the amount of electricity be insufficient to produce a conscious effect upon the exterior, the nerve cells are thrown into a state of excessive activity, mani-

[1] *Lancet*, August 18, 1906, p. 435.

festing itself in discharges of a purposeless motor and sensory nature, the 'bends' . . . the individual becoming polarised in the caisson. When decompression in the air-lock takes place, the rapid decomposition of electricity accompanying this and the fall of electric potential cause a similar effect." The personal equation is an important factor, for only thus can be explained the circumstance of one man after an exposure of one hour to a pressure of + 12 lbs. per square inch suffering from caisson disease, while another may be working for four hours in a pressure of 30 lbs. and not suffer at all. The electricity of the atmosphere in the caisson is hydro-electric in origin, and is due to the ordinary atmospheric air which is sucked in through valvular openings becoming compressed and propelled along several feet of metal tubing, wherein through friction of the more or less moist air against its walls, electricity is generated. The air which at ordinary temperature and pressure is a feeble conductor of electricity, obtains under pressure a heightened conducting power, a power which is greater if the air be moist. When men who had been tested by means of a Kelvin galvanometer before going to work in a caisson were examined after having been therein one hour, the deflections of the mirror were always much increased. Macnaughton, recognising the difficulty of explaining by the pneumatic theory compressed-air illness occurring in men one to two days after decompression, is of the opinion that the lesions in the brain and spinal cord are the result of rupture or the pressure effects of over-distended lymph vessels, an over-distension which is the conjoined result of pressure upon the body surface and the effect of muscular action upon the circulation. There is great similarity, he maintains, between the symptoms of a non-fatal lightning stroke and an attack of caisson disease, the return shock of lightning being physically comparable to the changes which follow a too rapid decompression after long exposure in a caisson.

Dr. Smith, of New York, attributed the illness to congestion of the brain and spinal cord, while Dr. Corning, in the *New York Medical Record*, 1890, attributes it to anæmia of the cord. It is clear from what has been stated in these pages

that there is still much to learn as regards the causes of caisson disease.

In this country men seldom work in caissons in higher pressures than 30 to 35 lbs. per square inch. That men can endure much higher pressures has been proved by the experiments of Messrs. L. Hill and M. Greenwood, junr.[1] Pressures varying from 75 to 90 lbs. were borne without any serious discomfort or distress so long as the Eustachian tubes were open and air could be swallowed. The period of compression extended over 54 minutes, and the period of decompression lasted 2 hours 17 minutes. Notwithstanding the length of time spent in decompression neuralgic pains in the arms were experienced. There was also considerable itching of the skin of the arms. On one occasion a purpuric rash appeared on the chest. Hill and Greenwood are of the opinion that to prevent symptoms the men on undergoing decompression should move their muscles and flex and extend their joints so as to aid the capillary circulation. These physiologists maintain that men can be submitted to a total pressure of seven atmospheres, or 105 lbs., without any untoward effects so long as decompression is effected gradually.

Treatment is preventive and curative. The Dutch Government has drawn out a series of excellent regulations for work in caissons. Having visited the tunnelling operations in Amsterdam necessary for the construction of a new railway viaduct, and having inspected the caissons and seen the conditions under which the men are working, I can bear testimony to the care which is taken of the workmen by the contractors, and have little hesitation in saying that the Dutch regulations are well up to date. A similar remark applies to the carefully drawn-up regulations which the French Government has prepared for the guidance of employers and workmen. Professor Langlois's paper is an important literary contribution to the subject of compressed-air illness.

At the time of writing the works at Amsterdam are not yet finished. Dr. G. Waller has kindly favoured me with the

[1] *Proceedings of the Royal Society*, Series B, vol. 77, April, 1906, p. 444.

following facts. One hundred and twenty-five men have been working in the caissons; of these 55 have had slight illness, most of these "bends," 9 have had ear trouble, 1 symptoms of Menière's disease, and 1 is deaf. An important innovation has been introduced whereby the compressed air sent into the caisson is cooled by an ammonia process as in the making of ice. This has answered most satisfactorily.

Men who are the subjects of nasal or laryngeal catarrh or who, on medical examination, are found to have diseased lungs or a weak heart, ought not to undertake caisson work, nor should any one who is known to be an alcoholic be allowed inside a caisson. All men ought to be primarily examined by a doctor. Young men between the ages of twenty and thirty, whose tissues are still elastic, men who are of rather spare than stout build and who are of regular habits, are the best subjects for caisson work. After the age of forty-five experience has shown that the liability to caisson disease increases. Too great attention cannot be paid to the evil effects of alcohol as predisposing to compressed-air illness. I have been particularly struck by this in looking over the statistics and history of the fatal cases of caisson disease at the River Hudson tunnel works. Workmen on being taken on for the first time should have the dangers of the operations fully explained to them. Since caisson disease is the result of the liberation of gas in the blood and tissues, consequent in many instances upon too rapid decompression, contractors, engineers, and physiologists have given considerable attention to this part of the subject in the hope of finding a remedy. The greater the depth men are working at and the longer the shift, the longer ought to be the time spent in decompression. The difficulty is to get the men to conform to this. Coming off the shift fatigued they are eager to get home, and as the process of decompression is attended by a very marked fall of temperature, the men, who are usually perspiring, feel chilly in the air-lock. In Amsterdam I found the owners provided the workmen with a blanket to wrap round their bodies in coming out of the air-lock. There is no reason why this chamber should not be heated. This would remove one of the causes of discomfort the men

complain of. Experienced workmen who know the dangers of rapid decompression are careful enough, but inexperienced men are disposed to run risks. One minute for every 5 lbs. of pressure was the time allowed at the King Edward Bridge on the Tyne for decompression. It is short compared with that recommended by Hill and Macleod, viz.:—

Atmosphere.	Pounds.	Shift.	Decompression Period.
+ 2	30	4 hours	30 minutes to 1 hour
+ 3 to 4	45 to 60	4 hours	1 hour to 2 hours
+ 5	75	1 hour	1 hour to 2 hours
+ 6 to 7	90 to 105	½ hour to 1 hour	2 hours

It would be difficult to restrain workmen this length of time in the air-lock undergoing very gradual decompression. The time spent by the workmen in the air-lock undergoing decompression should count as part of the shift. Wainwright, although of the opinion that rapid "locking-out" is a cause of caisson disease, and that if the process were sufficiently prolonged it would probably prevent subsequent symptoms, yet thinks that the three-quarters of an hour required to be spent in coming out of a pressure of 30 lbs. is, from an economic point of view, impracticable. He fails to see upon what grounds the precise mathematical rules drawn out by some writers are based. Slow decompression is most certainly called for, and yet it is known that men have made a practice of suddenly passing from high to low pressure by coming out of the caisson through the "material" or "muck" lock without experiencing any bad effects. It is facts such as these that the workmen point to as arguments against gradual decompression and which make them impatient when in the air-lock, and yet it would be unwise to allow knowledge of the freedom from symptoms in workmen who have occasionally adopted this unofficial method of exit

from the caisson to alter our recommendation of slow decompression. One minute for every 5 lbs. of pressure worked well enough on the Tyne—one minute for every 3 lbs. of pressure would even be safer. Wainwright says that at the Baker Street and Waterloo Railway tunnel it was possible to "lock-out" of 30 lbs. pressure in one and three-quarter minutes during the first three months of the excavating, but that afterwards the exit tap was altered, so that in order to leave the same pressure it required six and a half minutes. The alteration did not in the slightest degree alter the number or the severity of the cases. Snell, at the Blackwall Tunnel, had similar experience of the men undergoing rapid decompression without suffering.

When "bends" or more serious symptoms appear in men after they have left the air-lock, the best thing to do is to recompress them. At all works there ought to be a medical lock sufficiently large, so that the workmen can be laid in the horizontal position, and it should be sufficiently heated, so that all harmful influences of low temperatures may be avoided. Immediately upon the development of severe symptoms the workman should be placed in the medical lock and recompressed. The treatment is so successful for even muscular pains or "bends" that the men, knowing the relief they obtain from it, frequently ask to be placed in the medical lock and recompressed. Relief is often obtained after the pressure in the medical lock has risen to 18 lbs.; in other instances not until it has risen to 25 lbs., or 1 or 2 lbs. higher per square inch than the men had been working in. After a patient has been recompressed for some time, the pressure having risen to 20 or to 24 lbs., decompression should be extremely slow—an hour or even more should be spent in the process; or in other words, three minutes for every 1 lb. of pressure. The fact that symptoms do not develop for an hour or more after a workman has left the caisson, probably when he has got home, is no reason why he should not be taken back to the works, in a conveyance if possible, and placed in the medical lock and recompressed. Where no medical lock exists the ordinary air-lock can be utilised for the purpose of recompression, but the chamber

ought to be heated. Where patients are being treated at home or in hospital for "bends," the muscular pains may sometimes be so severe as to require the administration of morphia hypodermically. Other symptoms must be treated on their own merits.

It has been suggested by H. Von Schrötter that caisson workers should wash out the nitrogen absorbed during their work in high-air pressures by breathing pure oxygen for five minutes before entering the air-lock of decompression. Theoretically correct, the method has been proved to be experimentally efficient in preventing death from air embolism. It would be unsafe to allow oxygen to be used if men were working at pressures above 50 lbs., since symptoms of oxygen poisoning in the form of convulsions might develop.

Divers

Men who are engaged in diving for pearls and sponges, who are employed in searching for treasure in sunken ships or in deepening harbours by blasting rocks, run risks to health and life. When native pearl divers have once got over the initial pains in the ears and discomfort in the head, which all these men more or less experience, they can remain below the water for a sufficient length of time without artificial assistance in order to secure a few oysters, but they have to be careful of an open oyster closing and gripping their hand, for the grip when it occurs may mean to these men death by drowning.

Pearl divers off the coast of Australia occasionally go to a depth of 100 to 125 feet, but at this depth they can only remain a very few minutes. Salvage divers have recovered treasure at a depth of 160 feet without injury. Dr. Alfred Parkin, of Newcastle-on-Tyne, in his "Thesis on Caisson Disease," states that the greatest diving feat ever accomplished is that by Hooper, who made seven descents to depths of 201 feet (87 lbs. pressure to the square inch), and on one occasion remained underneath 42 minutes. In order to become accustomed to changes of pressure and to obviate immediate risks to life, a certain amount of time has to be

allowed both in descending and ascending. Neither must be rapidly done. Two feet per minute is the recommendation for the descent and ascent of divers when the depth does not exceed 80 feet, but as the depth increases so longer time must be allowed. A few minutes longer should be spent in ascending than in descending.

Sponge seekers, the scaphandriers of French authors, also run considerable risks. Not a year passes without several lives being lost. Through the kindness of Dr. Stef. Zografidi, surgeon to the Royal Grecian Navy, who has been in charge of the temporary hospital at Tripoli, Africa, and whose microscopical sections and drawings of the pathological lesions met with in the spinal cord of deceased sponge divers I have had the opportunity of examining, I am able to give some of the information he has gained in his researches upon 290 clinical observations and seven post-mortem examinations. It was Leroy de Méricourt, of the French Navy, who, in 1869, first drew attention to the dangers incurred by sponge divers by too rapid atmospheric decompression. Scaphandriers wear the diving dress invented by Denayrouse. Zografidi speaks of three forms of disease occurring in sponge divers as the result of rapid decompression, (*a*) the *acute* or *lightning* form, which ends in death; or (*b*) passes into the *chronic* state, accompanied by spasms; and (*c*) the *mild* form, which is fleeting in its duration. In the acute form death may be immediate, or if life continues for a time, there is a typical *myelitis* or inflammation of the spinal cord with fever and complete paralysis of the limbs. This form also usually ends in rapid death, or it is succeeded by chronic spasm of the limbs attended by loss of power. In the milder form of the malady the phenomena may pass away without leaving any trace of their existence. After a long stay at the bottom of the sea under a high pressure, the sponge diver, if he makes too rapid an ascent to the surface and thus undergoes too sudden decompression, may die immediately. In the worst forms of this malady the whole body is swollen and emphysematous, owing to the presence of air in the tissues; blood oozes from the nose, mouth, ears, and eyes, and there

are small hæmorrhages into the skin. These cases, fortunately, are rare. A less acute form, on the other hand, is not uncommon. Sponge divers descend three or four times a day, with the exception of Sunday, to depths varying from 100 to 250 feet. Under a low pressure they remain working for 40 to 60 minutes, under a higher pressure they stay a shorter time, but under all circumstances, Zografidi says, they come up far too quickly. The men live on board of small ships, and overcrowding is common. The ventilation of their sleeping-rooms is bad. Fatigued with the hard work of the day performed under the rays of an African sun, badly fed, for they live upon preserved foods which are highly salted and cause constipation, these unfortunate men, during six months of the year, follow a dangerous occupation both on the surface and at the bottom of the Mediterranean. The accidents to which they are liable are the same as those met with in caisson workers. Under high pressures the atmospheric air is dissolved in the blood and tissues, and during sudden decompression there is a rapid disengagement of the gas in the form of bubbles, which block the blood-vessels and tear the tissues. It is during decompression that danger is incurred. Sponge seekers who ascend too quickly to the surface of the water frequently complain of intense pain throughout the body, especially in the trunk, of derangements of sight and hearing, tingling in the limbs, followed shortly afterwards by paralysis. If it is a more severe attack there is loss of consciousness. After persisting for a few hours, the paralysis in some instances disappears for half an hour or longer, during which the sponge diver may get up and walk about feeling well, but a few minutes afterwards the tingling in the limbs returns, followed by loss of power in the limbs. For the next two or three weeks the patient lies a helpless wreck, paralysed in his lower extremities and with sensation abolished, complaining of a painful girdle sensation round the waist and retention of urine followed by incontinence. Fever develops, pus appears in the urine, and bed-sores form. The man dies from exhaustion and septicæmia, and in his spinal cord are found areas of inflammation and softening similar to those met with in caisson workers, and

due to the presence of bullæ of air and small hæmorrhages the result of the sudden liberation of gas. Dr. Zografidi says that the lightning form of the malady is always fatal, that in the acute form the mortality is 70 per cent., while in the mild form recovery is the rule. As regards treatment, there is, practically speaking, none beyond attention to general details. Oxygen is without any special influence. Zografidi has administered the gas to patients, who have died, and he has withheld it, and patients have recovered. The treatment of the paralysis is simply that of symptoms as they arise. Prevention is better than cure. When the decompression is not too rapid there are no accidents. Owing to the special mechanism of the diving apparatus invented by M. Shidlowski, of the Russian Navy, decompression in this apparatus can only occur slowly and gradually. Its use has been attended by good results.

The divers attached to the British Navy, and the men who follow diving for a living, wear a special dress and helmet. The dress may be either a "close" or "open" suit. The close suit is an air-tight indiarubber costume the shape of the body. Upon the upper part is screwed the headpiece with its window for seeing through. Attached to the headpiece is a conduit pipe for the fresh air, which is pumped in under pressure. By means of a valve the escape of the surplus and foul air is provided for. The whole body is under the influence of compressed air; but in the "open" suit, only the head of the diver is covered by a helmet screwed on to a jacket, and, as a consequence, the abdominal viscera may be exposed to considerable pressure. The air escapes from underneath the jacket too, so that if a diver falls his life is endangered.

Diving is now a recognised requirement in the British Navy. Before men can become qualified as divers they must give evidence of having dived to the depth of 120 feet and have shown themselves capable of being able to bear a pressure of 52 lbs. to the square inch. Apart from possible accidents arising through failure of the pumped-in air reaching the diver when at work, the principal danger lies in the ascent being made too quickly. When this has taken place, the

change from a compressed to ordinary atmospheric pressure has been too sudden, and, as a consequence, divers become unconscious or are found paralysed in their extremities, hence the name given of divers' paralysis to the malady. When divers have been pulled up too rapidly on board of ship some of them have died, and at the post-mortem examination the blood in the body has been found to contain bubbles of air. The spinal cord on section has been found lacerated, its small blood-vessels torn and bubbles of air readily recognisable.

In the Statistical Report of the Navy for 1900, Fleet-Surgeon Archibald McKinlay, R.N., tells of a man who dived for a torpedo in 24½ fathoms of water at Lamlash, Arran. He took 40 minutes to go down, remained at the bottom 40 minutes, and took 20 minutes to come up. The ascent was made by the seaman himself slowly, steadily, and without any hurry. He climbed up the ladder on the side of the boat himself. On the removal of the face-plate of the helmet the diver said he felt all right. He began to give a detailed account of what he had done; was sensible and cheerful and joked with the other men. About 8 minutes after coming out of the water he was suddenly seized with pain at the stomach and begged that the doctor might be sent for. Immediately afterwards he slid down and became unconscious. When Fleet-Surgeon McKinlay saw him he was comatose, "skin was cyanosed and his breathing stertorous, laboured, and difficult. His lips were blowing and covered with froth." He died about 15 minutes after coming out of the water, *i.e.*, 7 minutes after the commencement of his symptoms. At the post-mortem examination, which was made on the following day, a large quantity of dark fluid blood escaped from the vessels on the surface and base of the brain. Nothing abnormal was detected in the substance of the brain itself, but the veins of Galen, those on the surface of the brain and of the choroid plexus contained bubbles of air. The lungs were absolutely healthy and not the least engorged. The veins on the surface of the heart had a beaded appearance due to bubbles of air within them. On opening the right ventricle of the heart air came out with a

puff, and internally there was found a small quantity of black, frothy blood. The left heart was empty; the heart itself and valves were healthy. The liver was dark and engorged; on section the cut surface exuded large quantities of froth. The spleen was dark and contained frothy blood. From the cellular tissue in the subcutaneous fat of the body there escaped bubbles of air.

This man had been working at a pressure equal to 4½ atmospheres. It is interesting to note that two days previous to the occurrence of this accident another able-bodied seaman of the same battleship—H.M.S. *Howe*—descended to exactly the same depth, was at the bottom for 22½ minutes, took 18 minutes to ascend, experienced no inconvenience at the time, and had no bad effects afterwards.

Recent experiments undertaken for the Admiralty lead Haldane to recommend decompression in graduated stages, so that a "diver or worker in compressed air is brought rapidly to half the absolute pressure, stopped there for a time, then decompressed a little further after sufficient time has elapsed to allow the maximum nitrogen pressure in his tissues to become not more than twice the nitrogen pressure of the air at a lower stage. He is then brought on by further stages on the same principle until he reaches atmospheric pressure." For diving work stage decompression is the superior method even when effected quickly.—*Science Progress*, January, 1908, p. 389.

CHAPTER IV

DISEASES DUE TO DIMINISHED ATMOSPHERIC PRESSURE

ON the surface of the earth at ordinary levels man is living under a pressure of 15 lbs. aerial pressure to the square inch. He is no more conscious of this weight than when bathing he dives a few feet below the surface of the water. So elastic is the vital resistance of the human body that man can ascend to considerable heights or descend to great depths without discomfort, and even without serious risks, so long as certain precautions are observed. There are, however, limits to these attainments. The man who is climbing an Alpine peak has to lift his body a few thousand feet through an atmosphere that becomes rarer as he ascends, and as a consequence his heart beats more vigorously and even unpleasantly, and there is a sense of difficulty of breathing. There are added to the muscular effort of lifting the body through space the difficulties of getting oxygen into and carbonic acid out of the system. On reaching the summit men have been known to bleed from the nose. Although it cannot be stated that death has been caused by diminished atmospheric pressures at great heights, yet it has been shown experimentally in animals that coma is induced which may end in death. It is just a question how far the sudden supervention of cardiac and cerebral symptoms in mountain-climbers may not be responsible for some of the fatal accidents that occur from time to time on the Alps.

Altitude modifies the ordinary functions of the body in many ways. Such influences are in operation, for example, as diminution of atmospheric pressure or of oxygen tension,

cold, atmospheric electricity, and luminosity. The effect of luminosity is not exactly known. At high altitudes the atmosphere is more highly charged with electricity than is the air of the plains. It is not known what is the effect of this upon the body, nor of the light of high altitudes, which is rich in ultra-violet rays, the chemical activity of which is intense—a circumstance which, while explaining the frequency of the inflammatory redness of the skin of Alpine climbers, confers upon mountain air its purity and its freedom from germs. By these rays the air is rendered sterile. High up on a mountain-side the air is less dense, so that the same volume of air represents a smaller quantity of oxygen than in the plain. One might well ask, in view of this new respiratory medium, whether there is any change in the chemistry of respiration. To answer the question it is necessary to distinguish between respiration in the state of repose and in movement. According to Zuntz, Löwy, Müller, and Caspari[1] the number of respirations in a state of repose is not increased, but the amplitude of the respiration is augmented. The volume of air inspired is greater per minute, but the quantity of oxygen absorbed, if its volume is reduced to a pressure of 760 mm. of mercury, does not vary. During muscular exercise the number of respirations increases. The volume of air inspired, and consequently the volume of oxygen absorbed, reduced to 760 mm. of mercury, is much greater at high altitudes than it is in the plains for the same effort. Zuntz's experiments offer a physiological explanation of the breathlessness that occurs at high altitudes. Fatigue is increased not only from the fact of the chest being in one sense overworked, but because the products of organic combustion are increased and the circulation of these waste products in the system is a cause of fatigue. Auto-intoxication due to overwork readily develops after excessive exercise and betrays itself by insomnia and loss of appetite. It is apparent that if the effort which is exerted at high altitudes is greater than that required in the plains, the demand must be met by increased

[1] "Höhenklima und Bergwanderungen in ihrer Wirkung auf den Menschen," Berlin, 1905.

food, less of the nature of albumins than of carbohydrates and fats. At very high altitudes the quantity of oxygen in the air is insufficient for breathing purposes. In a similar way when men undergo too violent exercise the demand made by the body for oxygen is so great that the lungs cannot inhale air quickly enough. The result is the same in the two cases. There is anoxæmia, or what is sometimes called "le mal des montagnes."

Professor Mosso, of Turin University, whose work on "Fatigue" is well known, is rather opposed to the interpretation of the results by Zuntz. At great heights the respiration occasionally takes on the Cheyne-Stokes type, *i.e.*, a series of short and rapid inspirations gradually becoming slower and deeper and finally ceasing for a few seconds, only for a series of similar cycles to be repeated. This peculiar type of respiration has been attributed by Professor Mosso to a diminution of carbonic acid in the blood, for by giving inhalations of carbonic acid Cheyne-Stokes' respiration disappears. According to Mosso "le mal des montagnes," or mountain-sickness, is due to a deficiency of carbonic acid in the blood—a condition named by him *acapnœa*. Zuntz, on the other hand, maintains that there is sufficient carbonic acid in the blood to excite the respiratory centre to action, and that inhalations of carbonic acid do not dispel the symptoms of mountain-sickness. Oxygen alone can do this. At high altitudes man consumes more oxygen. The increased frequency of respirations is one of the most striking manifestations of the need of oxygen, and the increase in the number of the beats of the heart is a physiological consequence. To send the oxygen all through the body the heart must beat faster. In repose the heart beats slowly and at a certain rate—say 64 to 72 per minute—but a man has only to undertake a fatiguing walk for the pulse to rise to 120 or more per minute. Living at high altitudes is difficult and trying to persons who are the subjects of valvular disease of the heart. In health the heart and lungs at high altitudes adapt themselves to the rarefaction of the oxygen, and the blood behaves in a similar manner. By degrees there is established an increase in the number of the

red corpuscles of the blood, as well as of their colouring matter or hæmoglobin.

If I were to seek for an application of this physiological knowledge I could not do better than refer to the experience of persons who have travelled in trains at great altitudes. Some of the mines in Peru and Bolivia are high up on the mountains. Mr. Thomas Thomson, mining engineer of the firm of Messrs. Pearson and Company, London, tells me that in order to reach the great tableland of Peru the train rises 1 in 25 to 15,600 feet, and that at 13,500 feet mountain-sickness commences in the railway travellers with a sense of headache followed by a feeling of sickness, but there is no vomiting. There is a rush of blood to the head and flushing of the face, which travellers feel would be relieved if the nose would only bleed. Mr. Thomson's own pulse usually rose to 88 per minute and the respirations were proportionately quickened.

The men who work at the copper-mines at Cerro de Pasca, situated 16,000 feet above the sea-level, cannot follow the occupation long. They can only work for a few months at a time, when they are obliged to cease and return to their farms. The men work an eight hours' day in the mines. The influence of acclimatisation and heredity is noteworthy. The native labourers, who are Spaniards or of Spanish descent and who have been born at, comparatively speaking, high altitudes, bear the work better than other men. They can work longer without breaking down in health. White men, Europeans, cannot work at all in these mines, but they can superintend the work for about a year. The ordinary miners do not die from the effects of working under these conditions; they relinquish the work too soon for functional or organic disease to be established. At Cerro de Pasca the miners call the mountain-sickness *sorroché*. The 50 to 100 feet that the men go down into the mines has little effect in diminishing the effects of the great altitude already mentioned, viz., 16,000 feet.

What has been said of mountain climbing and of living and working at high altitudes applies to some extent to aeronauts. The only difference is the absence of muscular

fatigue, but against this must be placed the rapidity of change of atmospheric pressure. If the ascent is made very rapidly the system may have some difficulty in accommodating itself to changes of pressure. There is, too, the influence of exposure to greater cold. Persons ascending in balloons should dress warmly, and they ought to take with them cylinders filled with compressed oxygen. It remains yet to be seen what part balloons will play in military warfare. Both in the French and German Armies there have been several deaths of soldiers from poisoning by arseniuretted hydrogen. The hydrogen used for inflating balloons is obtained by acting upon zinc with sulphuric acid, but as the sulphuric acid is manufactured from pyrites which frequently contains 2 to 5 per cent. of arsenic, the impure hydrogen cannot but be inhaled during the filling of the balloons, and to this circumstance must be attributed the poisoning that occurs. The symptoms commence with a sense of malaise and nausea, followed later on by jaundice. The urine becomes dark and blood-coloured, and may contain albumen. Only pure hydrogen should be used for the purpose of inflating balloons.

CHAPTER V

CHEMICAL TRADES

UNDER the heading of chemical trades will be included principally the manufacture of chloride of lime, bleaching powder, sulphuric and hydrochloric acids. These are usually produced in one and the same factory as parts of one process. It is unnecessary to describe in detail the methods of manufacture known as the Le Blanc process, the Weldon and the Deacon process. Only a brief mention is possible. In the manufacture of soda or salt cake common salt is acted upon by oil of vitriol (sulphuric acid). When these are mixed together and raked on the bed of a furnace large quantities of hydrochloric acid are evolved, the vapour of which when breathed has a strong irritating influence upon the respiratory mucous membrane. This circumstance renders it impossible for the workmen to remain exposed to the vapour for any length of time, or to the gas which is given off when the salt cake thus formed is raked from the furnace into the barrows and wheeled away to undergo another operation in a different part of the factory. In order to protect himself from the hydrochloric acid fumes the workman wears folds of flannel round his face, for the acid fumes quickly destroy the teeth. As the work in the furnace department is hot the men perspire freely, and consequently run the risk of becoming chilled and of catching cold. When the chemical industry on Tyneside was more prosperous and gave employment to a larger number of persons than at present we were seldom without chemical labourers in the Royal Infirmary as in-patients. They were the subjects of chronic bronchitis with asthma and

emphysema of the lungs. The hours of the men employed in chemical factories are long, and in their work they are exposed to high temperatures. There are, therefore, many inducements to the men to become intemperate as regards the use of alcohol. Many of the men drink freely, for their wages are good.

After the salt cake leaves the furnace it is mixed with limestone and coal in a black ash furnace, and after being heated and stirred in the furnace a sufficient length of time the mixture is poured out in a molten form, cooled, broken up, and the soda dissolved out from it. This soda may be converted into soda-ash, soda crystals, or caustic soda. For the production of caustic soda the operations required involve boiling, furnacing, and other processes. When the caustic soda is in solution in large iron cauldrons and is hot it is apt to spurt and cause serious burns. In order to prepare bleaching powder slaked lime must be exposed to the freshly prepared chlorine gas obtained from hydrochloric acid given off during the operations at the salt-cake furnace. For a bleaching powder to be successful it ought to be capable of retaining 38 per cent. of chlorine gas. This is not readily secured; besides, when it is obtained the bleaching powder keeps constantly parting with its chlorine. Bleaching powder with less than 35 per cent. of chlorine does not sell well. It is, therefore, most important for the manufacturers to succeed in obtaining the extra 2 or 3 per cent. of chlorine. In the manufacture of bleaching powder by the Weldon process there is always a high percentage of chlorine present in the gas, and the method of manufacture is slightly different. Lime is spread upon the lead floor of large chambers, into which chlorine gas is passed. The doors are closed for three days, during which chlorine enters. The gas is absorbed. When the conversion of the lime into bleaching powder has been effected workmen enter the chamber. The mouth is protected by several rolls of flannel, but the nostrils are free. Leather goggles are worn to protect the eyes. The men shovel the powder through holes in the floor into casks underneath. The packing of the bleach is an unpleasant occupation. The men wearing the rolls of flannel round their face

take care to breathe through the mouth, and only allow the expired air to escape through the nostrils. Thus protected, and accustomed to breathe in the manner stated, a man may be able to stay in a bleach chamber for twenty minutes to half an hour or longer, during which time he is shovelling the bleach powder, but it is desirable that the workman should come out of the chamber into the open air every half hour and stay outside a short time before returning.

Most of us are familiar with the odour of chlorine. The gas has not only an irritating effect upon the respiratory mucous membrane, which may continue for several days, but it may also cause vomiting. In what is called the "gassing" of chemical workers, the symptoms are irritation of the bronchial tubes, a feeling of suffocation, and vomiting, symptoms fortunately of temporary duration, but which if often repeated may lead to structural alterations of the bronchial tubes and emphysema of the lungs.

Sulphuric acid is usually manufactured in the same chemical factories as soda. Sulphur, or sulphide of iron, is burned with the liberation of sulphuretted hydrogen. This gas is carried away into lead chambers, where it is brought into contact with air, steam, and nitrous fumes obtained by acting upon sodium nitrate with sulphuric acid. Although this is not such a hard occupation as the making of salt cake, the men who work at the pyrites furnace where the sulphur is given off are exposed to some extent to sulphur dioxide and to occasional nitrous fumes. These gases are irritating to the respiratory mucous membranes, and have much the same effect as chlorine and hydrochloric acid.

The Le Blanc process has had a lengthened career, but soda and chlorine can be produced by other methods, such as the electrolysis of salt. The passage of an electric current through salt solution breaks up the salt into chlorine and caustic soda, and when this decomposition has been effected the liberated chlorine can be led away for the purpose of making bleaching powder. Methods of manufacture die hard. There are indications that so long as there is the great demand for salt cake for making glass the Le Blanc process will probably continue.

Electrolytic methods are, however, gradually making progress in the manufactures, for by them there is often a saving of time. They are not always free from risk to health. In the manufacture of chloride of calcium, also of chloride of sodium and potassium by electrolysis, a peculiar skin eruption appears on the workmen. This dermatitis, which has only been detected during the last six or seven years, was first noticed among the men employed at Griezheim Factory in Germany. Since then the workmen employed at Motte-Breuil, in France, have also suffered. The malady is attributed to the hypochlorite of soda that is formed. The dermatitis usually affects young workers who have been in the factory a few days or weeks. It commences on the face by a crop of acne spots, and is attended by redness and œdema recalling erysipelas. The redness and swelling are pretty evenly distributed all over the face; the lobule of the ears is implicated and the eyelids are œdematous. Once the dermatitis has obtained a thorough hold the eruption may last for as long as fifteen days, and in disappearing leaves behind a few hard nodules and comedones on the skin. The swollen eyelids frequently become itchy and secrete a thin, purulent liquid, while the whites of the eyes becomes red and œdematous. Cough with laryngeal and bronchial irritation may be present. There is dyspepsia with loss of appetite. Emaciation is progressive, and there is extreme muscular and nervous debility. So marked is the tendency to sleep that many of the patients can hardly keep awake. The best treatment is the open air. As preventives, the ventilation of the factory should be good; the men should freely use soap, and wash in water acidulated with sulphuric acid, before leaving work. The application of vaseline to the unprotected parts of the body when at work is also well worthy of a trial.

Taking chemical workers as a whole it may be said that the younger men are not an unhealthy class. They become bronchitic and asthmatic as they grow older, and this too at a comparatively early age. Chemical workers on the whole enjoy good health until the age of 35, but after this the death-rate rises so that by the time they reach the ages of 45

to 55 the mortality rate of chemical workers is double that of men who follow an out-door occupation. Diseases of the respiratory system contribute largely to the high death-rate.

Nitrous and Nitric Acid Fumes

In the process known as "carotting" in the manufacture of felt hats from rabbits' skins the teeth of the workers become much affected (*vide* article "Mercury"). The skin is stretched upon a bench, and rubbed vigorously by the men, who keep dipping their brushes into a solution of nitrate of mercury. Occasionally the workmen make their own solution of mercury by dissolving 8 parts of quicksilver in 64 of nitric acid and then adding 4 of arsenic and 4 of corrosive sublimate. In preparing the solution the nitrous vapours that are evolved cause considerable cough and irritation of the lining membrane of the bronchi and lungs, and this may sow the seeds of future pulmonary trouble.

The acid fumes are of themselves dangerous. I can recall the occasion of a large fire in a chemical stores in Newcastle, when one of the firemen who were exposed to the nitrous and nitric fumes died a few days afterwards from a peculiar form of inflammation of the lungs. Most of the serious cases of nitric acid poisoning have arisen from accidental breathing of gases containing fumes. In chemical factories the men who work at the pyrites burners, in addition to being exposed to heat and cold, are brought into contact with sulphur dioxide, nitrous fumes, and other gases, all of them more or less irritating to the throat and lungs. Men employed in the manufacture of arsenic, arseniate of soda, picric acid, and in the manufacture of jewellery, especially the refining of the precious metals, are occasionally brought into contact with the fumes of nitric acid, but in a large proportion of the cases in which poisoning by fumes has taken place it has been through the accidental and unexpected escape of the vapour, inhalation of which causes cough, dryness of the throat, and sense of suffocation. A man who has inadvertently inhaled the fumes of nitrous or nitric acid may not exhibit any symptoms immediately, and

yet within from 24 to 48 hours he dies from acute congestion of the lungs, preceded by an abundant expectoration of thin, yellow material. The intelligence is retained to the last. At the post-mortem examination of the body the lungs are found to be intensely congested; there may be patches of reddish brown discoloration, in other words a patchy distribution of congestion which is always suggestive of the action of a toxic gas. The blood that is squeezed from the lungs is blackish brown. Nitrogen peroxide (NO_2) is clearly, therefore, a strong and dangerous irritant to the bronchial and pulmonary mucous membranes. It produces small foci of pulmonary congestion, and it causes the blood to become of a deep brown colour. The treatment—and it is seldom successful—is to overcome the painful condition of the throat and windpipe by the use of soothing gargles, and the bronchitis and pneumonia by the inhalation of oxygen.

Aniline

In the black dyeing of alpaca goods, aniline oil, when acted upon by hydrochloric acid, gives off fumes which cause the workmen to be ill. This method of dyeing cotton goods has been, in consequence, almost entirely abandoned. Aniline salt, which is obtained from aniline oil and is a dirty yellow-white crystalline substance, is instead usually mixed with the hydrochloric acid. In the Manchester factories the solutions used are aniline salt, prussiate of soda, and chlorate of soda as an oxidising agent. The cotton web, after passing through a trough containing the solution, travels onwards through a long, heated chamber. At this particular stage of the dyeing the men frequently suffer from the great heat and from the dust that is given off from the cloth. This part of the machinery ought to be protected by a hood, up which there should be a strong draught of air. The cotton cloth does not at once become black on being passed through the solution, but as it travels onwards it becomes black by exposure. The cloth, in travelling through an oven of indigo and steam, undergoes what is known as "ageing." From this it passes through a solution

of bichromate of soda. It is after receiving this immersion that the black colour becomes fixed in the cloth. On examining the hands of the men who work at the bichromate trough I have not found evidence of any induration of the skin or of cracks upon their hands. The colour can be fixed by such other substances as tannin and tartar emetic. In one of the large dyeworks near Paris which I had the opportunity of visiting the process was slightly different. The cotton web passed first through a solution of aniline salts, and after travelling a short distance passed through a second bath containing chromate of soda. Afterwards it kept moving onwards through hot chambers to be dried. Where more expensive aniline dyed goods are wanted the cotton, after its dip in the aniline salt solution, travels onwards through a heated chamber, and in doing so the cloth becomes olive green in colour through oxidation by the hot air. It is then dipped in the chromate bath and dried. The product thus obtained is said to be more durable than that got by the first method.

In what is called *para red* dyeing, the ingredients used frequently cause symptoms similar to those induced by aniline oil. The men experience headache, become sick, and are mildly intoxicated. They have to be taken out into the fresh air. The para red powder used in English dyeworks is a proprietary chemical compound obtained from Germany. The men who mix this material in the dyeworks, as well as those who throw the plastic stuff upon the cloth, suffer. The former are obliged, when scooping out the dry powder from the casks, to wear respirators. Para red is used for dyeing flannelette, which is nothing else than cotton cloth, one surface of which has been picked by sharp points and caused to be fluffy like flannel, but in which there is no wool at all. As I have mentioned flannelette, I need only add that it is an extremely inflammable substance and as it is cheap and frequently forms the underwear and nightdresses of children, it has been, and still is, every year, unfortunately, the cause of death of large numbers of children by their garments catching fire.

The symptoms of aniline poisoning are headache, drowsiness, a feeling of sickness with loss of appetite, shortness of

breath, palpitation, and a tingling sensation in the feet and legs. Dr. Walter Malden[1] on examining the blood of aniline workers did not find that it gave the spectrum of met-hæmoglobin, but this is not surprising, as the band of met-hæmoglobin can hardly be detected unless this substance is present in at least the proportion of 1 to 10 of oxy-hæmoglobin. Nor was there evidence of blood destruction to any extent, judging from the fact that the blood counts showed a normal average of red corpuscles. The colouring matter was reduced in amount, but the proportion of white corpuscles was not excessive. Malden is of the opinion that if there is a destruction of red corpuscles in aniline poisoning it is counter-balanced by a renovation of corpuscles, which, as it proceeds more rapidly than the formation of hæmoglobin, causes the colour index to be lower than in health, while the presence of basophil granulations in the red corpuscles points to imperfect formation of these cells or suggests that they are undergoing degeneration.

The health of workers in aniline has of late years much improved. During the summer months the workmen are apt to suffer most. The severe headache, vertigo, and sickness may not come on until they have left the factory and reached home.

Attention has frequently been drawn to the sudden development of rather alarming symptoms, especially in young children, the cause of which for a long time was obscure, but which is now known to be the use of a liquid rich in aniline oil for polishing the brown and fawn coloured boots and shoes that are so much worn at present. Children, when out walking with their nurses, have become rapidly blue in the face (cyanosed), the subjects of difficulty of breathing and of extreme muscular debility followed by somnolence. The symptoms occasionally assume a serious aspect, and the patients for the time being are really very ill owing to the poisoned condition of the blood. Exposure to the fresh air is, on the whole, the best treatment. The occurrence of these alarming symptoms has been generally traced to the use of a boot polish containing aniline oil.

Relm,[2] a German surgeon, has drawn attention to the

[1] *The Journal of Hygiene*, October, 1907.

[2] "Berliner Klinische Wochenschrift," vol. li., No. 19.

occurrence of twenty-one cases of tumour in the bladder among men employed in aniline works. Some of the men had worked 29 years—others only 5 years. The tumours were of a papillomatous or warty type in 3 of the men; in 18 the growths were sarcomatous or carcinomatous. Owing to the malignant nature of most of the growths, 11 of the patients had died at the time Relm published his paper.

Nitro and Di-nitro-Benzene; Di-nitro-Benzol

Owing to the odour of bitter almonds given off by nitro-benzene, this substance is made use of in the manufacture of perfumery and in cooking. It is also used in the manufacture of aniline. Workers in nitro-benzol factories are liable to attacks of giddiness and of unconsciousness, accompanied by blueness of the face or cyanosis. Inhalation of air mixed with nitro-benzol induces difficulty of breathing, and obliges the workmen to leave the factory and go out of doors. In the chronic form of poisoning there are headache, dizziness, and temporary loss of consciousness with cyanosis, symptoms which disappear when the men keep off work for a few days, provided they leave their working clothes behind them in the factory. Return to work is frequently followed by a reappearance of symptoms. The urine is dark, and the men are overcome by a desire to sleep. Muscular pains are complained of, and fatigue is readily induced. The eyesight is frequently affected. On examining the urine, traces of di-nitro-benzene will be found therein. In chronic cases of poisoning the di-nitro-benzene breaks up the red corpuscles of the blood, and alters its colour from a bright red to a chocolate brown. Malden[1] found di-nitro-benzene to be more toxic to the workmen than aniline and that the first recognisable sign in the blood of poisoning by di-nitro-benzol is the presence of basophil granulations in the red blood corpuscles followed by a diminution in the number of the corpuscles by 1 to 1½ millions per c.mm. of blood. He found in chronic cases an increase in the number of white corpuscles, especially lymphocytes, also in the more severe

[1] *The Journal of Hygiene*, October, 1907.

forms of poisoning a few nucleated red corpuscles and a trace of met-hæmoglobin as revealed by the spectroscope.

Benzene is converted into nitro and di-nitro-benzene, or myrbane, by the action of sulphuric and nitric acid. Myrbane is reduced to aniline by hydrochloric acid and iron.

In the manufacture of some of the high explosives, naphthalene and the aromatic nuclei, benzene and toluene, are made use of. The higher the nitration of the aromatic bodies is carried, the more dangerous becomes the manipulation of these substances. Di-nitro-benzene is a powerful poison, whether inhaled, swallowed, or injected into the circulation.

Dr. Prosser White, of Wigan, in "Dangerous Trades" gives a very full account of poisoning by di-nitro-benzene. When ordinary precautions are taken by the workmen, there is little risk to health. The workrooms must be well ventilated. It is desirable that the factory should be situated in the country. Cleanliness of the workroom and personal cleanliness of the men are requisites. Handling of the compounds should be avoided as far as possible, and everything done automatically and in closed-in machinery. Washing appliances and towels with soap should be ample. The temperature of the workroom should be kept low and dry, since moisture is usually followed by increase of sickness. In the winter months it is noticed that the amount of sickness usually declines. The workmen should wear special clothing and caps, and as the dust is liable to be deposited on the hair of the head and on the beard, it is better for the men to be clean shaven and for the hair to be worn short. There should be a medical inspection once a week, and all new hands should be medically examined before being allowed to work. As it is work that women sometimes follow, anæmia should be regarded as disqualifying. A similar remark applies to pregnancy. When symptoms of poisoning occur, the workpeople should be taken out of the factory into the open air, and if the cyanosis is well marked, it may be necessary to resort to the inhalation of oxygen, the application of warmth to the extremities, and the introduction of warm drinks by the mouth or rectum.

CHAPTER VI

EXPLOSIVES AND THE EFFECTS UPON HEALTH OF THE GASES EVOLVED

BY the term "explosives" is meant substances, solid or liquid, which through the chemical action induced in them by the application of heat or some other cause, become rapidly converted into gases which occupy a much greater volume than the original substance, and which become subsequently still further expanded by the enormous heat resulting from the chemical reaction. All kinds of ammunition are included under this designation, *e.g.*, gunpowder, nitro-glycerine, dynamite, gun-cotton, blasting powder, fulminate of mercury, &c. The chemical reactions that occur are explosion reactions. Once started in an explosion the reaction is propagated from molecule to molecule throughout the mass, and as the rate of the rapidity of this propagation varies between wide limits, it produces ordinary *combustion* when it progresses slowly, an *explosion* when it is relatively very rapid, and *detonation* when its velocity is almost infinite. These terms, however, are relative, for no hard and fast rule can be drawn between them, since in many instances the same explosive under different physical or mechanical conditions, or differently confined or ignited, may develop any of these phenomena. In order to produce their full effects, explosives of the gunpowder type require to be strongly confined, whereas with the more violent types of explosives, such as gun-cotton and nitro-glycerine, the degree of confinement can be very much less. An explosive reaction may be induced by friction or percussion, by contact with a heated or ignited body or by using a sensitive composition ignitable by percus-

sion or friction, and which in turn ignites the explosive. The effect produced varies with the particular manner in which the explosive reaction is induced. By the percussion of a small quantity of fulminate of mercury imbedded in nitro-glycerine or gun-cotton, an effect is produced which is much greater than the ordinary explosion of either substance itself. There is the almost instantaneous conversion of the whole mass of the explosive into gas or vapour. To this mode of explosion, as already stated, the term *detonation* is applied. Generally speaking an explosion is a form of combustion, but detonation cannot be explained quite in the same way. Heat alone will not produce detonation, a sudden shock is also required. Detonation is the effect produced by combined chemical and dynamical reaction.

According to the purposes for which they are employed explosives are called *high* and *low*, but these terms are purely relative. In *high* explosives the chemical transformation is very rapid and energetic: they are usually fired by detonation, and the effect is more or less local. High explosives contain a large percentage of oxygen, and are usually definite chemical compounds. When the chemical reactions are transmitted comparatively slowly through the mass the effect produced is a propulsive one and the substances employed are called *low* explosives. Propulsive explosives are employed to impart motion to projectiles so that they travel with great rapidity through the air. For the purpose of our immediate inquiry it is with the "disruptive" explosives, or those which are used in mines and quarries and which produce crushing or shattering effects, that we are mostly concerned.

Explosive compounds contain carbon, hydrogen, oxygen, and nitrogen, the last named being always feebly combined with the oxygen in whole or in part. It is this instability of chemical equilibrium that is so essential, for when an explosion occurs the nitrogen molecule "readily parts with its oxygen to the carbon and hydrogen, for which it has a great affinity, forming carbonic acid, carbon monoxide gas, and water."[1] The hydrogen produces by its combustion an

[1] "Treatise of Service Explosives," 1906.

extremely high temperature, so that the water which is produced is in the form of greatly expanded steam.

Gunpowder has during the last five centuries of its use in Europe varied little in its composition. It is a compound of saltpetre, charcoal, and sulphur. It is not the manufacture of gunpowder that concerns us, but the gases that are formed after its explosion and the effects of those gases upon men working in mines and quarries. During the decade ending 1899 there occurred the following number of accidents in the handling and use of the various explosives ("Dangerous Trades," p. 605):—

Nature of Explosive.	No. of Accidents.	Number of Persons	
		Killed.	Injured.
Gunpowder	244	94	294
Nitro-glycerine compounds ...	376	135	440
Ammonium nitrates	44	12	41
Detonators	143	3	193
Fireworks...	41	19	96
Total	848	263	1,064
Total in manufacture during same period	175	44	204

Until recent years gunpowder was extensively used as an explosive in British coal-mines owing to its comparatively slow action, but it is deficient in oxygen, and should the carbon which it contains be only partially burned carbon monoxide is formed. The amount of carbon monoxide formed varies from 2·4 per cent. upwards. The drawbacks to the use of gunpowder in coal-mines are the heavy odour of sulphur that remains after the firing, also the smoke and development of carbon monoxide.

Gun-cotton, discovered by a German chemist, Schönbein,

in 1846, has been proposed as a substitute for gunpowder owing to the fact that it possesses the power of burning without creating smoke and without leaving any residue. The explosive is prepared by immersing carded cotton in strong nitric acid and then carefully washing it. So many fatal accidents and explosions occurred during its manipulation that for several years the manufacture of gun-cotton was abandoned, but by removal of the free acid or any nitrogenous material that might be present there have been fewer accidents. Gun-cotton has neither smell nor taste. It retains the appearance of the cotton from which it is made, only it is slightly harsher to the touch.

Nitro-glycerine, discovered in 1847 by an Italian chemist, A. Sobrero, of Turin, remained more or less a chemical curiosity until the well-known Swedish engineer, Alfred Nobel, began to manufacture it in large quantities for blasting purposes. For years it met with very limited success. After long research and many experiments Nobel succeeded in mixing nitro-glycerine with an inert substance, *kieselguhr*, a porous infusorial earth, which rendered it less sensitive and enabled it to be transported with safety. This compound is known as *dynamite*. By substituting for the kieselguhr an active explosive like nitro-cotton another explosive is obtained, viz., *blasting gelatine*. When blasting gelatine is frozen it is much more liable to be exploded by a blow. It is a more powerful explosive than dynamite. From mixtures of nitro-glycerine and soluble nitro-cellulose *ballastite* and *cordite* are obtained.

Pure *nitro-glycerine* is a clear, heavy, oily liquid, almost colourless, without smell at ordinary temperature, and with a sweet taste. When inhaled its vapour causes intense headache, which exposure to the fresh air or a cup of strong black coffee usually relieves. Nitro-glycerine can be easily detonated by friction or percussion. The readiest method of detonating it is by a fulminate percussion cap. It is not easily ignited by a flame.

Tonite consists of gun-cotton and nitrate of barium in almost equal proportions.

Lyddite is obtained from picric acid. The stories that

were in circulation at the time of the South African War as to the destructive effects upon the enemy of the explosion of lyddite shells and of the poisonous character of the fumes that were liberated were much exaggerated. The lyddite shells when they exploded threw up great clouds of sand and stones and produced a greenish-yellow smoke. At Paardeburg the shells exploded harmlessly in the mud on the soft banks of the river in which the enemy had burrowed. "The whole of Cronje's laager was mapped out with great yellow patches of picric acid powder, but few casualties were attributable to lyddite." At Bergendal, an irregular kopje of rocks protected by earthworks, the Johannesburg Zarps made a good stand. Lyddite shells were rained upon the place until it became untenable. On the third day the Boers hurriedly fled from the position, leaving twelve dead and a few men wounded. One of the prisoners seemed at first as if he had jaundice—the skin of his face and hands was of a bright yellow colour, and he was labouring under intense nervous fear. In a few days all his nervous symptoms had disappeared. Lyddite appears to have little destructive effect in the open, but in a confined space its effects can be extremely severe.

Accidents in the Manufacture and Use of Explosives

There is no industry in which the possibility of sudden death and complete annihilation is greater than in the manufacture of explosives, and yet the number of victims claimed by the industry is fortunately small. Legislation has accomplished much. The men and women employed in explosives factories belong to the better class of work-people. Knowledge of the dangerous nature of their calling causes them to exercise the greatest care and cleanliness. Major Cooper Key, H.M. Inspector of Explosives, tells us in "Dangerous Trades," p. 602, that there are 11,098 persons employed in this country in the manufacture of explosives. During 1899 there were 54 accidents in the factories, in which 3 persons were killed and 24 injured. The deaths per 1,000 persons employed in the manufacture

of explosives for the ten years ending 1899 are given by Major Cooper Key as follows:—

	Killed.	Injured.
Gunpowder	·52	1·2
Nitro-glycerine	·42	1·4
Ammunition, exclusive of detonators ... ... Fulminate Composition ...	·23	2·2
Fireworks	·77	2·9

While death by accident in the manufacture of explosives is possible, there is no danger to the health of the operatives. In the manufacture of nitro-glycerine the persons employed often suffer from headache for the first few days on commencing work. With renewed experience this tends to disappear, but will reappear should the individual absent himself from work for a few weeks. The women who mix the kieselguhr and nitro-glycerine, although they must absorb nitro-glycerine, do not seem to suffer to any extent.

Accidents occur during the storage of explosives, but it is during their use that accidents are more likely to happen, for familiarity in this instance too often seems to breed contempt. Particularly is this the case in mining. During 1899 there were no less than 29 persons killed in mines and 195 persons injured by explosives. Several of the accidents were due to men scraping out the detonators with pins, thawing dynamite over the fire, driving dynamite and gunpowder into roughly drilled holes, and boring out misfires.

Setting aside these accidents, many of which are the result of carelessness, we have to deal with the effects upon miners working in confined spaces of the gases liberated during detonation. Many of the miners complain of violent headache and vomiting. They suffer from palpitation of the heart, become more or less collapsed, and only recover after they have been taken into the fresh air. When brought to bank the men are pale and look ill. Soon the symptoms pass

off, especially if vomiting has taken place, but in many instances the patients have to be taken home, put to bed, given warm drinks, and have warmth applied externally. Many of the miners whom I have examined a few days or weeks after the "gassing" have been the subjects of extreme nervousness and of a sense of dread attended by want of confidence in themselves. Inhalation of the fumes given off by those high explosives disturbs the nervous mechanism of the heart. The beat of the heart is excessively rapid, and the men complain of unpleasant sensations in the precordial region. Some of the men are more liable to be affected than others. There is an idiosyncrasy to the fumes given off during an explosion of nitro compounds. No doubt some of the men have themselves to blame for becoming gassed, as they return to the particular part of the mine too soon after the explosives have been fired, and time is not given for the fumes to be cleared away.

In the manufacture of *fulminate of mercury* there is the double danger of inhaling harmful emanations and the risk of explosion. On the addition of alcohol to a solution of acid nitrate of mercury, there is produced in the liquid mass considerable seething, during which there rises the vapour of nitrous ether. It is this vapour which, on account of its ready inflammability, has been the cause of numerous fires and which exercises upon the men who breathe it a harmful influence, for the workmen complain of severe headache coming on suddenly, vertigo, loss of consciousness, numbness of the extremities, and a sense of constriction of the chest, which may be accompanied by cyanosis.

CHAPTER VII

DISEASES DUE TO METALLIC POISONS, DUST, FUMES, ETC.

INDUSTRIES IN WHICH LEAD IS EMPLOYED:—LEAD POISONING; SATURNINE POISONING; PLUMBISM; PAINTERS' COLIC

General Review of the Subject

THE evil effects of lead have been known for centuries. More deaths have been caused by lead than by any other metal, partly because no other metal enters so largely into the arts and industries as lead, also because of the silent and insidious manner in which the poisoning occurs. Lead exerts its malign influence with a rapidity and severity greater in young persons than in old. Young adults especially are quickly brought under its sway. As a form of industrial poisoning it is met with among persons who inhale the dust and fume, who manipulate soluble lead compounds, or handle the metal itself. Metallic lead *per se* has less poisoning power than its salts, and of its compounds the most important in this respect are the carbonate, oxide, and chromate, because these are most employed in the industries. The death-rate from lead poisoning, directly and indirectly, is high. As an indirect cause of death the association of the two is not always recognised. Usually it is easy to diagnose plumbism in its early stages, when it presents such symptoms as colic and is accompanied by the presence of a blue line on the gums, but as a cause of chronic ill-health, disease of internal organs, and slowly developed structural changes in the nervous system, the relationship may not in many instances even be suspected. The evil effects of lead poisoning are often widely spread through a community, for

owing to the use of lead pipes for conveying drinking-water into dwelling houses, the use of lead cisterns for storing water, the cooking of food in lead enamelled utensils, the consumption of tinned meats and fruits frequently contaminated by the lead dissolved out of the solder, also the large number of industries in which lead in one form or another is made use of, the metal and its compounds have many opportunities of exerting their harmful influence upon man.

Plumbism the result of drinking contaminated water and consuming tinned food does not come within the scope of this article. All that need be said of this part of the subject—and the remark applies to lead poisoning generally—is that the metal, when taken into the system in small quantities and in a soluble form for a period, operates so insidiously that the individual, hardly conscious of the gradual loss of health, ultimately feels that his health and strength have become so undermined that he can no longer work, or without any warning he is suddenly seized with acute abdominal pain or with a paralysis that persists for weeks or months.

Owing to foreign competition and the greater richness of foreign ores in silver, lead mining in England is no longer the source of wealth or of industrial activity of bygone days, and as a consequence fewer men are employed in the mines than formerly. With certain foreign ores it pays the British smelter to extract the silver and treat the lead as a by-product. The lead-miner does not suffer from plumbism owing to the fact that the ore contains lead in almost a pure metallic state, but at the Broken Hill mines in Australia the ore contains lead in the form of carbonate, and several of the miners there have died from saturnine encephalopathy, or the cerebral type of lead poisoning attended by convulsions. Lead is also found in nature in the form of sulphate. It is an interesting fact that at the Broken Hill mines, owing to the fumes from the smelting furnaces, the vegetation in the immediate neighbourhood is scanty and ill-grown, and that the common fowls which pick their way about the grounds a large proportion die from lead poisoning. Dr. Macdiarmid, who has been living at the lead mines at Linares, Spain, informs me that fowl-keepers in that district complain of the hens laying eggs without a firm

supporting shell. I have never succeeded in producing this tendency in hens, although, like other animals, they can be readily poisoned by lead. Fowls lose the power of walking, they stagger a good deal and frequently fall, and their urine contains albumen. In lead-smelting districts, *e.g.*, Leadhills in Scotland and in the dales of County Durham, the fumes from the furnaces poison the pasturage of the neighbourhood, and cattle grazing thereon have died from lead poisoning. At Bleiberg, in Belgium, I found the same accidents had happened, and that the owners of the works had had to pay heavy compensation to the farmers for the loss of their cattle. While hatching fowls in an incubator I found that if a portion of a hen's egg is painted with a neutral solution of lead acetate development of the chick is arrested and on opening the egg that the embryo is dead. Painting the surface of other eggs in a similar way with a strong solution of lime is not attended by death of the embryo. While lead is destructive to the higher forms of life, it is not so to all of the lower forms. In an interesting paper on the "Immunity of Some Low Forms of Life from Lead Poisoning," Mr. T. W. Hogg[1] gives the results of a series of examinations which he made on earthworms which inhabited a waste bark heap in a large lead works. The heap consists chiefly of the old bark taken from the white lead stacks with sweepings from the yards, and amounts to 20,000 tons, as it is the accumulation of over sixty years. The bark is impregnated with lead, varying from 1·5 to 2·5 per cent., and away from the surface it is in a damp, pulpy condition. To a great extent it has become converted into a kind of vegetable mould. Notwithstanding the large amount of lead present in the bark, the waste heap in the summer months teems with animal life, especially with the common earthworm. The bark contains nutritive material. In the intestines of the worms there is usually found a considerable quantity of finely divided bark, so that when worms are desiccated and dried at 100° C. the quantity of lead found corresponds closely with that present in the bark itself. Earthworms consist approximately of 80 per cent. of water and 20 per cent. of organic and mineral matter. Hogg

[1] Society of Chemical Industry, Newcastle Section, February 28, 1895.

found that the amount of lead, estimated as lead protoxide, present in the organisms varied from 0·37 to 0·52 per cent. This is a large quantity of lead, but when the intestines were freed from their contents and thoroughly washed the amounts varied from 0·009 to 0·018 per cent., a circumstance which shows that only very small traces were retained in the cellular lining of the alimentary canal. Although an extremely small quantity, even this amount of lead is greater than that which is found in the internal organs of men and women who have died from industrial lead poisoning. Professor Bedson, of the Armstrong College of Science, made for me several analyses of the brain, liver, and kidneys of male and female lead workers who died under my care in the Newcastle Infirmary, and while the largest amount of lead was usually found in the liver, the proportion present in the grey matter of the brain was in some instances only 0·00053 per cent. Hogg on microscopically examining earthworms treated with a solution of ammonium sulphide found that the only part of the body which became dark and therefore showed the presence of lead was the intestinal wall. Beyond that the metal did not appear to pass. An interesting question therefore arises as to how it is that earthworms possess an immunity to lead. The answer is probably to be found in the operation of their calciferous glands. On squeezing out the secretion of these glands and treating it with ammonium sulphide no trace of lead was detected. How this secretion should offer any protection it is difficult to say. When serving with Professor Thorpe on the Pottery Commission we learned that there was an opinion widely held by the workmen in Staffordshire that those who drank a particular ale did not suffer from plumbism. In this ale Professor Thorpe found a fairly large percentage of sulphate of calcium. That calcium salts confer immunity I am not prepared to say. In the pottery worker the immunity above referred to is probably rather the result of slow absorption, owing to the conversion of soluble lead compounds in the alimentary canal into the less soluble lead sulphate, than of any real protection that is afforded. Darwin estimated that a single worm ejected 20 ounces of soil per year. Given the same immunity from lead poisoning

as that possessed by an earthworm weighing 22 to 25 grains, a man would be able to swallow annually several times his own weight of white lead, and to retain continually one pound of it in his system without exhibiting symptoms of poisoning. It may be that this immunity of the earthworm is part of a resistance begotten by successive generations or it is an illustration of a similar power which other organisms possess of growing luxuriantly in poisonous media, as witness certain moulds in arsenical and mercuric solutions, also of the power which certain birds possess of eating the deadly strychnos nux vomica with impunity.

Lead Mining: Smelting: Desilverising

Lead miners do not in this country suffer from lead poisoning, but, as the mines are badly ventilated, are often wet, and entrance into and exit from them can only be effected by means of ladders, the men suffer in their general health and from rheumatism. In the dales of Durham, house accommodation near the lead mines is difficult to obtain. Consequently many of the men have long distances to walk from and to home. At the end of a day's work, when heated and fatigued, they are thus exposed in winter to the cold winds that sweep along the valleys. Bronchitis and lung diseases claim a large number of victims. The deadliest enemy is tuberculosis. Formerly, when lead mining was more of an industrial success than it is to-day, the men were housed in barracks close to the mines, and returned to their homes at the week-ends. These barracks were overcrowded and badly ventilated, and were hotbeds of tuberculosis. In the sleeping-rooms not only was the air space insufficient and the beds too close to each other, but the windows were never opened, and miners who were the subjects of bronchial catarrh and tuberculous lung disease simply expectorated on the floor of the dormitories. Overcrowding, the breathing of foul air and of the dust-laden atmosphere of the sleeping-rooms favoured the spread of tuberculosis. As a consequence of these and of exposure to severe weather, also inattention to "colds on the chest," lead miners, although living in healthy districts, have

succumbed to phthisis in much larger numbers than other persons living in the same district.

So far as industrial plumbism is concerned, the danger to health commences with the smelting of the lead ore. During the year 1906, 38 cases of lead poisoning occurred in smelting works, 24 of which were in lead works. The fumes which are given off, if not carried away from the face of the workmen, are apt to cause poisoning. Since furnacemen therefore run considerable risk, all furnaces should be hooded. The fumes are often caused to travel a great distance through flues, often high enough for a man to stand in them, and sometimes half a mile in length, before being allowed to escape. From each ton of metallic lead that is smelted 130 lbs. of lead will be given off as fume. It is the fume from lead-smelting furnaces which poisons the pasturage and causes the death of cows and sheep that graze on the fields in the neighbourhood. Smelters occasionally suffer from lead poisoning and its consequence—kidney disease. There is an idiosyncrasy to plumbism, more marked in some persons than in others. I have known member after member of a family—all strong, healthy young men who had been employed as smelters—die from lead poisoning and its sequelæ, while their comrades escaped. Animals are rapidly destroyed by flue dust. The cleaning out of the flues is a most dangerous occupation, for the dust is nearly all oxide and sulphate of lead, and unless the passages are freely ventilated men cannot work in them for more than two hours at a stretch without suffering from severe headache and becoming generally ill. After cleaning out the flues the men should have a warm bath.

Instead of allowing lead thus to escape, which is a loss to the manufacturer, the fumes could be passed through water under pressure, and much of the lead thereby recovered. It is impossible to recover by rapid methods all the lead. At the Mies Works, in Austria, the fumes, after passing through leaden chambers to be cooled, pass on through fifty chambers which are kept wet with sprays of water in order to precipitate the lead and absorb the sulphur. From these chambers the fumes are led through wooden tubes and through a portion

of a disused mine. Notwithstanding all this attempt to recover the lead, the fumes on escaping are found to contain 14 per cent. of sulphur and 4 per cent. of lead. At other works the liquid from the spray chambers is passed over limestone, whereby the sulphur and any arsenic that may be present are absorbed and the lead precipitated in the lime, from which it is obtained by drying.

Since lead contains a fairly large quantity of silver, this has to be extracted by means of making an amalgam of lead with zinc in the molten state. This method of desilverising, which is known as the Pattinson process, is not attended by lead poisoning to any great extent; still, I have met with cases of plumbism in desilverers. A fatal case of plumbism in a desilverer was reported to the Home Office in 1906. Although the men are exposed to high temperatures, and the ladling out of the molten metal is rather laborious work, yet it cannot be said that the men—generally a better class of workmen—suffer as much as the nature of their employment might lead one to expect. The melting down of old scrap lead, tea lead, old lead pipes, &c., is attended with greater risk to health than the use of the pure metal, partly because proper precautions as regards hooding of the melting pots and ventilation are not taken, the amount of fume is considerable, and there is more litharge (oxide of lead) dust raised during the ladling of the molten metal.

Red Lead: Litharge, Massicot, Lead Oxide

In the manufacture of red lead the metal is simply roasted in a reverberatory furnace and raked from time to time. A considerable amount of fume escapes from the mouth of the furnace, and unless this is hooded and a strong draught provided to carry it away, the workmen may become poisoned. The red lead is removed in large pieces, placed in barrows, and allowed to cool. It requires seven to eight hours to convert metallic lead into litharge. During the grinding of red lead large quantities of fine dust are raised. To inhalation of the dust, as well as to the fumes, must be attributed the symptoms of plumbism met with in the workmen. Red lead workers

form from 1 to 2 per cent. of all the cases of plumbism reported to the Home Office.

When litharge which has been washed and dried is again placed in the furnace, roasted afresh, and raked so as to become further oxidised, it is converted into what is known as yellow litharge.

In red lead works the furnaces are placed along one side of the building, but it would be an advantage to have them in the centre of the room, so that men could walk round the furnaces; to have the building lit from above and not at the sides, and to have the roof high and the walls smooth, so that as little dust as possible might collect upon them. The floors should be made of cement or bricks, and not, as in too many instances, the ordinary soil. Iron floors are objectionable on account of their slipperiness. The advantage of cement floors is that they can be brushed or swilled with the hose. In England most of the walls of red lead factories are rough and begrimed with dust; in Germany the regulations are that the walls shall be painted, so that they can be washed; while in Austria two whitewashings per annum are regarded as sufficient. Young adults should not be allowed to work in white lead works nor in the red lead furnace, grinding, and packing departments, nor ought women to be employed therein.

A few years ago at Klagenfürt White Lead Works, in Austria, during a period of scarcity of adult labour, the men begged the employers to allow their sons to work in the factory. Lads under eighteen years of age were consequently given employment. These youths, all of them of good physique, well-developed, and healthy looking, were examined medically before entering the factory, and yet, notwithstanding this precaution, so great was the amount of lead poisoning amongst them, and in such a short time, too, that the employers were obliged to dismiss them.

The use of tobacco under any form should be prohibited in the factory. Disregard of this regulation should be visited by a penalty. There should be a special room set aside for the clothes of the workmen. In Great Britain the wearing of overalls in dusty departments is required, but in Austria a Commission which sat in Vienna in 1905 recom-

mended the provision of three suits of clothes, (1) for ordinary use, (2) for cleaning purposes, and (3) for reserve. The recommendation of the Austrian Committee could hardly be carried out in England, owing to the large amount of casual labour in lead factories. Both in white and red lead works I have always been in favour of alternation of employment, *i.e.*, the undesirability of allowing workmen to remain too long in dangerous departments, and the gain to health obtained by shifting them from inside to outside work, and *vice versâ*, has been considerable. I have seen the advantages of this in the large white lead works of Messrs. Expert Besançon & Cie., in Paris, where the men follow out a scheme of alternate employment. The registers of Messrs. Besançon's factory contain a carefully kept biographical account of each workman and of the number of weeks spent in each particular department, so that years afterwards, by referring to the register, information is at once obtained as to what a workman was doing on a particular date. One of the effects of supplanting hand labour by machinery is that, as fewer hands are required, it is more difficult to carry out alternate employment. The wearing of a simple moist respirator, fixed by a band round the head, is a safeguard in dusty processes. It has been recommended that an apparatus should be worn such as that used in mines after an explosion or in places containing foul air. If this were to be adopted a simpler and less expensive form of apparatus would have to be invented. Too great stress cannot be laid upon the necessity for personal cleanliness. It is the want of personal cleanliness which makes casual labour in lead works more dangerous than constant employment. In England and Scotland white lead workers are taken from the poorest and most indigent classes: many of them, having lost their regular employment through intemperance, gladly seek work in lead factories, but they are not fit subjects for the occupation. Allusion has been made to the provision of clothes for the men when in the factory. These clothes—blouses and loose trousers narrowed at the foot—ought to be washed regularly once a week, and the washing should be done by machinery. I have known several instances of women whose duty it was to wash

the clothes of the workmen employed in lead factories losing the power in their hands and suffering from acute lead poisoning. Bath-rooms should be provided at the works, otherwise it is impossible for the men to have a warm bath, owing to the poor condition of their homes. The men should be obliged to take a bath at least once a week, oftener if they have been engaged in dusty processes. Washing the hands in water containing a small quantity of acetic acid and various forms of soap have been recommended. What is required is cleanliness, even to the removal of the dust from underneath the finger-nails. Unsatisfactory as the lead industry is from a health point of view, much good has been effected in recent years by enforcing the regulations and by the monthly medical examination of the workers, with power given to the factory surgeon to suspend when necessary. This examination is shirked by several of the employés, and especially by the casual workers, to whom the shilling fee is a matter of some mportance. Where the medical examination has been systematically carried out nothing but good has resulted, but even this procedure does not confer complete immunity, for experience shows that workers who have passed the doctor and who have been pronounced as satisfactory have the same day been taken ill with symptoms of acute plumbism.

Lead Industries. Manufacture of White Lead

Notwithstanding the progress of science and the improvements in modern industrial methods, poisoning by lead and its compounds continues to be a disconcerting fact to legislators, a disappointment to employers, and a source of ill-health to a large number of the working classes. Reference has already been made to the insidious manner in which plumbism develops. It cannot be too strongly asserted that some of the worst types of lead poisoning are more frequently the result of the daily entrance into the system of minute quantities of lead than of large doses. This is probably due to the fact that lead in minute quantities is more likely to be absorbed, and is an explanation of the fact that by the time symptoms develop the workman has already received into his

system a fair quantity of the metal or its salts. Attempts have been made to underestimate the amount of industrial lead poisoning, and to attribute a share of the plumbism in certain manufacturing districts to women swallowing diachylon pills for the purpose of procuring abortion, while by other writers several of the accidents of saturnism have been regarded as the outcome of indulgence in alcohol. In my Goulstonian Lectures on lead poisoning I give the results of a series of experiments upon animals, to which alcohol as well as lead was administered in the food, and it was conclusively demonstrated that alcohol precipitated attacks of plumbism, a fact which in the human subject clinical experience has again and again confirmed. There is not the least doubt that alcoholic intemperance predisposes to lead poisoning. In a lead worker, who is also the subject of alcoholism, it is not always easy to differentiate between the symptoms caused by alcohol and those due to lead. In consequence of this fact there has been among certain writers a disposition to assign to intemperate habits a special rôle in the development of symptoms which, unless due care is taken, may mislead, since the symptoms may, after all, be the result of occupation. Double wrist-drop is one of the common phenomena of lead poisoning; on the other hand, paralysis of the feet and legs is of frequent development in chronic alcoholism, the wrists usually being spared. Occasionally, however, these may suffer. The nerves selected and the muscles affected are in the two forms of poisoning quite distinct, and yet in consequence of loss of power in the hands in white lead workers and house-painters it is sometimes stated that the men following these avocations are more intemperate than others of the working classes. With no wish to brand one class of workmen as intemperate compared with another, the habits of the working classes of different districts are interesting in regard to lead poisoning. In a Report on the white lead industry presented to the French Senate by M. Treille a marked difference is shown to exist between the northern and southern divisions of France. The intemperate habits of the working classes of Normandy and Brittany are well known. These two districts give employment to one-third

of the total number of house-painters in France, and yet within their borders the death-rate from plumbism is more than one-half that of France. Chronic cases of lead poisoning are much more prevalent in the north than in the south. Normandy alone with its heavy consumption of alcohol has more than one-half of the total cases of lead paralysis in France. The influence of alcohol in these cases, as in all, is to reduce the vital resistance of the nerve cells of the workman, to render him careless as to the necessity for cleanliness, and thereby to render him more prone to plumbism. Another circumstance which predisposes to lead poisoning is working in lead before having breakfasted. If there is one fact which the experiments carried out on my behalf by Professor Bedson demonstrate, it is that if food is present in the stomach at the time a workman commences work in a white lead factory in the morning, he runs much less risk of lead poisoning than his comrade who goes to the factory without having broken his fast. Owners of white lead factories would not only be doing a humane act, but rendering an economic service, if they provided their hands with hot coffee, tea, or milk and bread before commencing work in the early morning.

The prevalence of lead poisoning in Great Britain and Ireland, and the influence exerted by Home Office regulations and medical inspection may be seen from the table on page 149, extracted from the Annual Report of the Chief Inspector of Factories for the year 1906.

There has been a discontinuous diminution in the number of cases of industrial lead poisoning since 1899, and in no branch of industry is this more apparent than in the manufacture of white lead. It was largely on my recommendation —when a member of the White Lead Commission—that the Home Office by regulations abolished female labour in the dangerous processes of white lead manufacture. Although the recommendation was opposed at the time by almost every white lead manufacturer in the country on economic grounds as well as those customarily connected with the trade, employers now admit that nothing has so purified the lead industry of what was to them a source of worry and a cause of

dissatisfaction to the public as the removal of women from the stripping of the white beds, washing of the white lead, filling and emptying of the stoves, and other dangerous processes of manufacture. Notwithstanding the exclusion of women from work in the white beds of a white lead factory, there is still a large number of women employed in the works, whose condition, Miss Paterson, H.M. Inspector of Factories, tells us, calls for constant supervision. Manufacturers are not considering their own interests, nor the reputation of the trade, when they employ females in the factory. Knowing how ex-

Disease and Industry.	Number of Cases Reported.							
	1906.	1905.	1904.	1903.	1902.	1901.	1900.	1899.
LEAD POISONING	632	592	597	614	629	863	1,058	1,258
Smelting of metals ...	38	24	33	37	28	54	34	61
Printing	16	19	15	13	19	23	18	26
File-cutting	15	12	20	24	27	46	40	41
Tinning and enamelling	18	16	13	18	14	19	16	24
White lead	108	90	116	109	143	189	358	399
China and earthenware	107	84	106	97	87	106	200	249
Litho transfers	5	5	3	3	2	7	10	11
Glass	4	3	—	4	8	11	7	8
Electric accumulators ...	26	27	33	28	16	49	33	32
Paints and colours ...	37	57	32	39	46	56	56	75
Coachmaking	85	56	49	74	63	65	70	65
Shipbuilding	26	32	48	24	15	28	32	30
Paint used in other industries	37	49	27	46	44	61	50	54
Other Industries ...	100	118	102	98	117	149	134	183

tremely prone women are to lead poisoning, it is not with astonishment we learn that plumbism is still frequently observed amongst women employed in such subsidiary processes in white lead works as dusting and washing the "acid" pots removed from the white beds and the dry carbonate boxes from the stoves. I have seen young women die from acute lead encephalopathy within four months after commencing work in a white lead factory. In a case reported by Miss Paterson[1] the girl had worked less than

[1] "Annual Report of the Chief Inspector of Factories for 1906," p. 212.

two months when she became the subject of plumbism. Employers cannot be too frequently reminded that the susceptibility of females to lead poisoning is greater than that of males, and that the symptoms are usually of a graver character. Apart from the influence of sex, women's wages are smaller, and they are therefore less able, if fighting the battle of life alone, to obtain proper food, which, as already stated, is a protection to some extent against plumbism.

Formerly Newcastle and Tyneside were hotbeds of industrial lead poisoning. To-day cases of plumbism are few and far between. Until the crusade against lead poisoning there was hardly a week passed without patients thus affected seeking advice at the Royal Infirmary, and scarcely a month went by without there appearing in the daily press the announcement of the death of a lead worker, usually a young female. All this is changed. It is a rare event to have in our Infirmary wards a patient suffering from industrial lead poisoning, and especially a female in-patient. The declension in the number of cases of industrial plumbism has taken place without a reduction in the total number of persons employed. In 1892 there were 44 patients admitted into the Royal Infirmary, Newcastle-upon-Tyne—15 males and 27 females; in 1900 there were 14 patients, all males; since 1900 it has been a rare event to have even one patient the subject of industrial lead poisoning.

It was in 1898 that the Home Office abolished female labour in the dangerous processes of white lead manufacture. Until that date there is not the least doubt that females had been employed in larger numbers than males in the dangerous processes; but, apart from this circumstance, females are more prone to plumbism than males. This applies pretty generally to the female sex of all animals. In addition to sexual proclivity to plumbism, there is a family and individual idiosyncrasy to it as well. Members of some families are more predisposed to lead poisoning than others.

In order to appreciate the difference in the degree of

danger to health in some processes of white lead manufacture compared with others, the methods of manufacture may be briefly described. Most of the white lead sold in this country is made by the old Dutch process, which consists in the transformation of metallic lead into the white carbonate by a slow and double process of conversion. Numerous earthenware pots, containing 3 per cent. of acetic acid, are placed on tan in a large three-walled chamber, and upon these pots are laid thin strips of metallic lead, and subsequently planks of wood. Tier after tier of pots, resting on bark and covered with metallic lead and wood, are thus superimposed until the chamber, 25 to 30 feet in height, is filled to within 6 feet from the top. This chamber, known as the "blue" bed, is now closed in front by wooden planks or doors, and kept closed for fourteen weeks or longer. Fermentation occurs in the blue beds, the temperature rises, and carbonic acid is evolved from the bark, escape of the excess of which is provided for at the top. The acetic acid vapour acts upon the lead and converts it into acetate of lead, while the carbonic acid evolved from the bark changes the acetate into carbonate, the well-known white lead of commerce. Usually there is little danger run by persons employed in making up a blue bed, and yet a little while ago in one factory there were eleven out of twelve cases in women who had inhaled the dust. It is when the conversion of the metallic lead into carbonate has occurred that the first danger in the manufacture is encountered. This occurs during the emptying or stripping of what is now called the "white" bed, and if sufficient time has not been given for the very soluble acetate to have become changed into the carbonate the danger is thereby greater. The white beds should not be disturbed until the conversion is complete, nor should men be allowed to empty the white beds as piece work, as they are sure to hurry over the task, careless in regard to raising dust and heedless of the necessity of spraying with water.

During the stripping of the white beds there is a considerable quantity of dust raised, a large part of which is white lead, and unless spraying with water is effectually carried out the workers cannot avoid inhaling the dust. Formerly

the stripping of the white beds was mostly done by female labour, but on account of the large amount of sickness among the women so employed the work had to be abandoned. In emptying a white bed the lead carbonate is found as a thick white incrustation on the metallic lead, for all the metal is not completely converted. This is picked off and conveyed to the wash tubs, where it is put through rollers and washed. The material is collected, placed in jars or boxes, and subsequently carried to the "stove," a chamber composed of shelves, and upon which the jars containing the washed white lead are deposited. When filled the door of the stove or drying chamber is closed, and the temperature gradually raised to 70° C., and kept thus for forty-eight hours. The temperature of the stove must not be raised too quickly, otherwise some of the lead carbonate will be changed into lead oxide, as shown by the presence of a delicate pink colour. In two days the stove, after having cooled down, is emptied. After its removal the white lead is ground and mixed with oil to make paint, or it is packed into casks and sold as dry white lead. The filling of the barrels is a dusty process, and ought to be carried on in a closed chamber freely ventilated.

The drawing of the stove is a dangerous process, and ought not to be undertaken until the temperature has fallen. In removing the jars filled with dry white lead there is a considerable amount of dust raised. It is work for which women are ill-suited on account of their dress raising dust, and yet the drawing or emptying of stoves was, until 1898, almost entirely effected by females. I have known healthy young women, after a few days' work in the stoves, so completely shattered in health as to be obliged to relinquish the work permanently.

Knowing the proclivity of women to plumbism, I have always felt that I was justified from a medical and social point of view in having pressed for the abolition of female labour in the white beds, stoves, and the dusty processes of white lead manufacture; and while at the time I was much abused for my pains, it is gratifying to know that, by excluding women from these processes, death has been averted, much human

suffering spared, and that there has not been the dislocation in the trade employers feared, nor the difficulty of obtaining male labour, which was advanced as a reason against the change. As bearing upon the greater danger to health in some processes of the manufacture compared with others, the figures of the Medical Inspector of Factories are of interest. Between January and October, 1898, there were reported to the Home Office 191 cases of lead poisoning. Of these the stoves supplied 76 patients and stripping of white beds 31. The ages of the patients were:—

Under 20 years.	20–30.	30–40.	40–50.	50–60.	Over 60.
7	84	58	24	15	1

In four-fifths of the total cases the malady took the form of colic, and in the remaining one-fifth there were paralysis and cerebral symptoms. On February 17, 1898, the Home Secretary (Sir M. White Ridley) announced in the House of Commons that there had been 37 cases of lead poisoning in factories and lead works among boys under 18 years of age which had proved fatal. Work in a white lead factory is not an occupation for young persons of either sex: the employment of young persons has consequently been largely discontinued. It is interesting to know that neither dogs nor cats can live in a white lead factory. Machinery is replacing hand labour in white lead works. Formerly women could be seen carrying on their head at a time from one department in the factory to another two or three boxes filled with white lead, also one box under each arm. All this has, fortunately, been abolished. The work is done by mechanical means, and with good results, as will be mentioned later on.

Much of the danger in white lead works is explained by the circumstance that, since most of the work is unskilled, considerable dependence has to be placed upon casual labour. This, with irregularity of employment, is an element in the problem of industrial plumbism that must not be overlooked. Men who are regularly employed in a white lead factory know the dangers to health, and while admitting that even with them familiarity often breeds contempt, still

these men, notwithstanding their lengthened service, are less frequently ill than newcomers who do not appreciate the danger. Dr. T. Morison Legge found that of 1,463 persons employed off and on in white lead works, the incidence of lead poisoning was 6 per cent. of the average number regularly employed, and in those casually employed 39 per cent. Out of 13 factories with regular employment, 4 had no cases of plumbism to report, even although in one of these factories 110 persons were employed; whereas from two factories in which there was a large amount of casual employment 50 cases of plumbism were reported. This is quite in keeping with my own hospital experience. The largest number of patients admitted into the Newcastle Infirmary always came from one particular factory—one, too, not always employing the largest number of hands. The explanation is not difficult. Apart from greater structural defects in one factory compared with another, also more lax supervision of the workers and deficient provision of washing appliances, the *personnel* of the workers is of some importance, for casual labourers are careless in their habits and wanting in personal cleanliness, they frequently indulge in alcohol to excess, they chew tobacco when at work, and as many of them have been out of work for some time they have not had the means to obtain proper food. These, singly and combined, predispose to industrial lead poisoning.

It is unnecessary to detail other processes of white lead manufacture, since they are not made use of to any extent in this country. In the chamber process acetic acid is placed on the floor and strips of metallic lead are suspended on wooden frames; the carbonic acid is obtained from burning coke and is conveyed directly into the chamber, the windows and door of which are hermetically sealed. In eight or ten weeks the conversion is complete. In this method the use of tan is done away with, but there is the same danger incurred in removing the lead carbonate from these chambers as in stripping the white beds. Spraying with water is necessary. The precipitation process of white lead manufacture calls for only the briefest description. It is made use of in France, where it is known

as Thenard's method of white lead manufacture. Basic acetate of lead is first formed. This is subsequently decomposed by means of carbonic acid, but the white lead thus produced is not amorphous, and is altogether an inferior product compared with that obtained by the Dutch method. In America white lead is made by electrolysis. Nitrate of soda is decomposed by electrolysis in presence of a lead salt. Nitrate of lead is the result. This is acted upon by means of caustic soda so as to form lead hydroxide. By acting upon the hydroxide with sodium bicarbonate white lead is obtained, but it has inferior covering powers, and is too crystalline compared with that produced by slower methods. In this country there is a strong feeling in favour of white lead made by the old Dutch method. Since it is generally regarded as a finer product, it usually commands a higher price.

So far as the manufacture of white lead is concerned, the processes that are dangerous to the workpeople are those in which the atmosphere is dusty, for the dust, being mostly white lead, is either swallowed or inhaled. If swallowed, the white lead is converted in the stomach, by the hydrochloric acid of the gastric juice, into a soluble chloride which is readily absorbed into the blood; if inhaled, the dust is deposited in the alkaline mucus secreted by the respiratory passages and absorbed. Lead may also be absorbed through the skin, as we know from the use of hair dyes and ointments containing lead: also through open wounds on the skin. Dust is the enemy to be avoided by the white lead worker. It is raised in the stripping of the white beds, emptying of the stoves, and in packing. Spraying with water, by allaying the dust in the white beds, has rendered this process less dangerous, the filling and emptying of stoves by mechanical means has robbed the stoves of much of their danger, while improved methods of packing, but especially the immediate transference of the white lead from the white beds to the mixing department, where it is ground, washed with water, and subsequently mixed with oil, and thus converted into paint straightaway, without ever having been handled at all, has rendered the manufacture of white

lead and paint a much less harmful industry than it used to be.

In white paint there is, on an average, 75 per cent. of lead carbonate and 25 per cent. of oil. Before it is used house-painters frequently add to it a small quantity of turpentine, or a little oil with some drying agent, such as borate or oxalate of magnesia or burnt alum. The men who mix the paint do not suffer to any extent from plumbism. They do not handle the compounds, but simply lift the finished product with wooden spades. The wet processes connected with white lead manufacture and its compounds are, comparatively speaking, but not entirely, free from danger, as the subjoined figures show. In two white lead factories the workers who suffered from plumbism were made up as follows:—

	No. of Cases.	Per Cent.
Stripping white beds	42	29·0
Making up blue beds	31	21·3
Packing dry white lead	20	13·8
Paint mills	17	11·7
Casting	10	6·9
Stoves	8	5·5

In these factories the stoves had been so modified as to have removed much of the danger incidental to the work carried on therein. That the stoves and white beds can be the cause of lead poisoning to a greater extent than other processes is shown by the following figures obtained from H.M. Medical Inspector of Factories of 192 cases of plumbism:—

Stoves in conjunction with white beds and rollers ...	76
White beds alone or in conjunction with blue beds ...	31
Rollers	16
Labourers	23
Indefinite	46
	192

Since dust is the enemy to be avoided, the workpeople are recommended to wear respirators. That respirators entangle a considerable quantity of dust was shown by the late Dr. Dupré during the sitting of the White Lead Commission, also by Mr. Rogers, H.M. Inspector of Factories, who found in the respirators worn by persons working in a yarn dyeworks 0·0034 gramme of lead when the fans were running and the atmosphere fairly free, and when the fans had been stopped 0·02 gramme. There does not appear to be any particular season of the year during which the number of cases of lead poisoning is greater than in another.

In no works, from a health point of view, are the good effects of spending money on fresh plant more apparent than in white lead factories. It has been, and still is, in some places the practice for boxes of white lead to be carried by the workpeople from one department of the factory to another, *e.g.*, from the white beds to the wash-tubs and stoves. This is not only a slow method of transit, but a dusty one as well. Mechanical lifters and carriers worked by electricity are used in many factories with greater safety as regards the health of the workpeople and saving as to time and labour. By such means, as well as by mechanical stoves having supplanted hand labour, the gain effected has been considerable. In the factory of the Union Minière de Bleiberg the number of cases of plumbism fell, as a consequence of this substitution, from 55·2 to 19·1 over a period of ten years, although the production of lead compounds had more than doubled; and in the white lead works of Newcastle-upon-Tyne equally satisfactory results have followed the introduction of mechanical lifters and carriers.

Manufacture of China and Earthenware

Next to the white and red lead industries, the trade which gives the largest number of victims of plumbism is that of china and earthenware. The manufacture of pottery is a good illustration of how an industry becomes rooted in a district. Nine-tenths of the china and earthenware produced

in England are made in Staffordshire, especially in the towns of Stoke-on-Trent, Burslem, Hanley, Longton, Fenton, and Tunstall, collectively spoken of as the "Potteries," and yet the finer clay from which the earthenware is made has all disappeared from Staffordshire. The coal, however, remains, and cheap fuel is an element in the manufacture of pottery that cannot be ignored. At the present time the fine clay has to be brought from Cornwall. The manufacture of pottery in Staffordshire is an old industry; it goes back more than two hundred years. At that date clay was plentiful in the neighbourhood. The ware was made from yellow or red marl, and glazed with galena, a crushed raw lead ore brought from Derbyshire. In 1680 common salt was substituted for galena in the glaze. In 1759 Wedgwood improved the manufacture of white cream ware, and introduced the green, black Egyptian, and jasper wares. Since then the production of pottery in Staffordshire has gone up by leaps and bounds. Staffordshire has supplied more of the world's markets with china and earthenware than the pottery districts of any other country. She feels the keenness of modern competition, and is struggling hard to maintain the supremacy. Upwards of 70,000 tons of ball clay are annually delivered into the "Potteries" from the south of England. Kaolin, the Chinese word for the clay out of which porcelain is made, is in Staffordshire called china, or Cornish clay, and is obtained from ground granite. It is unnecessary to describe at length the manufacture of pottery. Suffice it to say that, so far as domestic ware is concerned, once it is shaped or moulded it is placed in the oven and fired. The ware is then known as *biscuit*. Some ware, such as terra-cotta and stoneware, requires only one firing, but all other ware has to be fired twice. Previous to the second firing it is dipped into a liquid glaze, which usually contains a quantity of lead. The lead in the glaze may be the ordinary carbonate, *i.e.*, white lead, or the lead compound may first have been fired with other substances and vitrified. This gives it the appearance of glass, and renders the lead more insoluble. The lead in this form is spoken of as having been "fritted." When ground and mixed with fine clay and water it

forms a white liquid like chalk, and is a safer glaze for the workmen than the glaze made from raw lead. By the term "fritted lead" is meant a compound of raw lead (carbonate), silica, and boric acid, &c., fused together at a high temperature. The resulting product is extremely hard, and is sparingly soluble in acids. Into the glaze, no matter how made, the ware is dipped. When dried, each piece is smoothed and cleaned. Where the glaze contains only raw lead, the dust which is given off during the cleaning of the ware contains a large quantity of lead carbonate, and as the dipper's assistants cannot but inhale some of the dust, this is one of the dangerous processes of earthenware manufacture, for many of the hands thus employed suffer from lead poisoning. Once the ware has been smoothed it is carefully packed in saggers, large coarse earthenware dishes, and placed in the oven to undergo a second firing. Owing to the high temperature the glaze on the surface of the dipped article melts, and gives, when cooled, the gloss seen upon cups, saucers, plates, &c.

China or porcelain differs somewhat from earthenware. The porcelain manufactured in Limoges, France, is made from kaolin, felspar, and quartz; a softer kind is made at Sèvres, near Paris; while in England porcelain is made from kaolin and Cornish stone, with calcined bone added to it. For hard porcelain the glaze is made from felspar, in which there is always some quartz, while for other kinds of porcelain the glaze usually contains silicate of lead and borax. The presence of lead in any glaze allows of a lower temperature being used for the biscuited ware, and thereby of a saving of fuel being effected.

Roughly speaking, there are fifty thousand persons employed in Staffordshire in the manufacture of china and earthenware. Ten years ago the large number of cases of lead poisoning in the "Potteries" created a good deal of public interest and dissatisfaction, which found vent in such hostile criticism that the subject was discussed in Parliament. The Home Secretary appointed Professor Thorpe, of the Government Laboratory, and myself in May, 1898, to make a special inquiry into the matter, and to ascertain—

"1. How far the danger may be diminished or removed by

substituting for the carbonate of lead ordinarily used either (*a*) one or other less soluble compound of lead, *e.g.*, a silicate; (*b*) leadless glaze.

"2. How far any substitutes found to be harmless or less dangerous than the carbonate lend themselves to the varied practical requirements of the manufacturer.

"3. What other preventive measures can be adopted."

Singly or together, Professor Thorpe and I not only visited the potteries in Staffordshire and Scotland, but also several of the leading manufactories on the Continent, *e.g.*, Delft, La Louvière, Maestricht, Copenhagen, Charlottenburg, Dresden, Limoges, Choisy-le-Roi, and Montereau, &c. Our opinions and recommendations to the Home Secretary are embodied in a Blue Book which was presented to the House of Commons in February, 1899. These recommendations were as follows:—

"1. That by far the greater amount of earthenware of the class already specified, *i.e.*, *white and cream-coloured ware*, can be glazed without the use of lead in any form. It has been demonstrated without the slightest doubt that the ware so made is in no respect inferior to that coated with lead glaze. There seems no reason, therefore, why in the manufacture of this class of goods the operatives should still continue to be exposed to the evils which the use of lead entails.

"2. There are, however, certain branches of the pottery industry in which it would be more difficult to dispense with the use of lead compounds. But there is no reason why, in these cases, the lead so employed should not be in the form of a fritted double silicate. Such a compound, if properly made, is but slightly attacked by even strong hydrochloric, acetic, or lactic acid. There can be little doubt that if lead must be used, the employment of such a compound silicate—if its use could be insured—would greatly diminish the evil of lead poisoning.

"3. The use of raw lead as an ingredient of glazing material, or as an ingredient of colours which have to be subsequently fired, should be absolutely prohibited.

"4. As it would be very difficult to insure that an innocuous

lead glaze shall be employed, we are of opinion that young persons and women should be excluded from employment as dippers, dippers' assistants, ware cleaners after dippers, and glost placers in factories where lead glaze is used, and that the adult male dippers, dippers' assistants, ware cleaners, and glost placers should be subjected to systematic medical inspection."

It was impossible that these recommendations should be received with general approval. We were dealing with an old-established industry. Trade customs die hard and new methods of manufacture are costly. However wishful pottery manufacturers might be to adopt our recommendations, there were financial and economic considerations that could not be ignored. As no unanimity could be arrived at between employers and the Home Office as to the means by which plumbism in the potteries could be diminished, a compromise was effected, but the matter had ultimately to be referred to arbitration. The Court sat at Stoke-on-Trent in November, 1901, and was presided over by Lord James of Hereford. Previous to this, however, there had been much that led up to arbitration, as the sequel shows. The use of leadless glazes for certain goods, the more frequent use of fritted lead in the form of a double silicate, abolition of raw lead in the glaze, and the exclusion of young persons and women from the dipping and ware-cleaning departments and as glost placers, were the principal recommendations made by Professor Thorpe and myself. There was not the least doubt that at the time the inquiry was undertaken raw lead had been used by the Staffordshire pottery manufacturers with far too free a hand, and it was clear that this could not go on, judging from the amount of lead poisoning in the trade. As to what the quantity of lead in the glaze should be, the master potters themselves were divided. Some manufacturers stated that 20 per cent. of lead was required, while others thought that 10 per cent. was sufficient. Professor Thorpe found excellent examples of lead-glazed ware in which the lead monoxide did not exceed 12 per cent. of the total weight of the glazing materials, while in the liquid obtained from the dipping tubs (*i.e.*, the glaze solution) of some of the manufac-

turers he found the lead varied from 13 to 24 per cent., and even higher. As a result of the trend of events at this date, and of Professor Thorpe's experiments and recommendations, a conference of representatives of manufacturers and of the Home Office was held at the Home Office on October 31, 1899. Two months afterwards the Home Secretary (Sir Matthew White Ridley) intimated that he intended after a certain interval to propose that there should be in potteries a standard of insolubility of fritted lead for glazes, the standard of insolubility being that the glaze should not yield more than 2 per cent. of lead when acted upon by hydrochloric acid under certain conditions. The manufacturers considered the 2 per cent. of insolubility too hard a requirement, and suggested 5 per cent. instead. The main object of the inquiry undertaken by us was to suggest means whereby lead poisoning in potteries might be diminished without doing any serious injury to a trade which, both at home and in foreign markets, was severely hampered by unlimited competition. The attention of manufacturers was drawn to the fact that if the standard was fixed at 5 per cent. this would allow of the use of a glaze from which it was possible in one hour to extract one-third of the lead by dilute acid at ordinary temperatures, and that this would only perpetuate the evils that were then existing. Meanwhile employers, working under Special Rules issued four years previously by the Home Office, were doing something to improve the methods of manufacture, so that when the Arbitration Court met at Stoke-on-Trent statistics were put forward which showed that a notable declension in the number of cases of lead poisoning in the potteries had occurred—a fall from 12 to 3·5 per cent. This circumstance, which of itself was ample proof that the inquiry had been necessary, also showed what could be done by the manufacturers themselves when stirred to action, and was earnest of what might yet be accomplished. This apparently was the view taken by Lord James, for after a five days' sitting of the Court he postponed arbitration for eighteen months, so that manufacturers might have the opportunity of giving the Special Rules a longer trial, that additional experiments with fritted lead might be

made, and that a scheme of mutual assurance might be established between employers and workpeople.

The adjourned arbitration took place at Stoke-upon-Trent on June 30 and July 1, 1903, Lord James of Hereford, as heretofore, acting as umpire. The object of the meeting was to consider and discuss statistics relating to cases of lead poisoning which had occurred in potteries since the meeting held in November, 1901, and to settle upon some definite course in regard to certain points in the rules which had been so hotly disputed eighteen months previously, viz.: (*a*) the use of fritted lead in the dangerous and dusty processes, (*b*) no glaze to be used which yields to a dilute solution of hydrochloric acid more than 2 per cent. of its dry weight of lead calculated as lead monoxide, and (*c*) monthly medical examinations of the workers, with power of suspension by the certifying surgeon. In closing the inquiry Lord James announced that he would give his decision in writing within three weeks. The text of his award became the basis of a series of Amended Rules which were issued by the Home Office, and in which the spirit of compromise is apparent. Since the fritting of lead if performed in a slovenly manner is only a false protection, this was not made compulsory. No glaze was to be used which yielded to 0·25 per cent. solution of hydrochloric acid more than 5 per cent. of its dry weight of lead calculated as lead monoxide, there was to be a monthly medical examination of workers employed in certain specified processes, with power of suspension by the certifying surgeon, casual workers were to be examined at their own expense, a health register was to be kept, overalls and head coverings were to be provided and maintained by employers for women and young persons employed in certain specified processes, respirators were to be worn by persons in the mixing of unfritted lead compounds and in the preparation of fritts and glazes, drying stoves were to be ventilated, the floors of the workrooms were to be sprinkled and swept daily, and a scheme of compensation for lead poisoning arranged. Under these Amended Rules the trade has been practically working since. It would be an advantage if a special room were set aside in the factory for the monthly

medical examination of the workpeople. Funds and existing arrangements do not admit of the certifying surgeon being a purely Government official, but it would be a gain generally were he such. He would be more independent of employers than the local surgeons who at present discharge this function.

The subjoined table supplies information as to the number of cases of lead poisoning in the Staffordshire potteries before arbitration and since:—

	1906.	1905.	1904.	1903.	1902.	1901.	1900.	1899.
From the North Staffordshire Potteries District	85	75	84	75	66	84	165	204
From other Districts in the United Kingdom	22	9	22	22	21	22	35	45

Taking the total number of cases of lead poisoning occurring in several of the important departments of china and earthenware manufacture and reported to the Home Office, the following statistics, extracted from the Annual Report of the Chief Inspector of Factories for 1906, are of value:—

TOTAL CASES REPORTED AS OCCURRING IN—

		1906.	1905.	1904.	1903.	1902.	1901.	1900.	1899.
Dippers	M.	23	12	20	16	11	19	36	38
	F.	5	4	8	1	4	4	5	17
Dippers' assistants ...	M.	4	4	—	6	3	4	9	13
	F.	19	15	20	18	12	11	23	21
Ware cleaners ...	M.	1	3	—	3	2	1	6	3
	F.	18	14	26	15	19	23	44	33
Total in dipping house	M.	28	19	20	25	16	24	51	54
	F.	42	33	54	34	35	38	72	71
Majolica painters ...	M.	—	1	—	—	—	1	—	—
	F.	7	7	7	10	3	5	8	25

PROPORTION OF CASES TO PERSONS EMPLOYED

		1906.	1905.	1904.	1903.	1902.	1901.	1900.	1899.
		Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Dippers	M.	2·9	1·5	2·6	2·0	1·5	2·5	4·8	5·0
	F.	3·8	3·0	6·1	0·8	3·9	3·9	4·9	16·5
Dippers' assistants...	M.	0·9	0·9	—	1·3	0·6	0·8	1·9	2·7
	F.	4·9	3·9	5·2	4·7	3·3	3·0	6·3	5·8
Ware cleaners ...	M.	1·0	3·0	—	3·0	2·0	1·0	6·0	3·0
	F.	4·1	3·2	5·9	3·4	4·1	5·0	9·5	7·2
Total in dipping house	M.	2·1	1·4	1·5	1·9	1·2	1·8	3·8	4·0
	F.	4·4	3·4	5·6	3·5	3·8	4·1	7·8	7·6
Majolica painters ...	M.	—	3·3	—	—	—	10·0	—	—
	F.	1·3	1·3	1·3	1·8	0·6	1·0	1·6	5·0

The numbers of persons employed in the dipping-house were, in 1900, 1,336 males and 929 females; and in 1904, 1,336 males and 963 females. The percentages for the years 1906 and 1905 are calculated on the return of persons employed in 1904. The total numbers of persons employed in processes in which lead is used were, in 1906, 4,224 males and 2,148 females, or a total of 6,372; in 1904, 4,394 males and 2,300 females, or a total of 6,694 males and females. The number of fatal cases, in which lead poisoning contracted in earthenware and china works is stated to have been directly or indirectly the cause of death, was 16 out of a total of 31 from all industries in 1899, 8 out of 38 in 1900, 5 out of 34 in 1901, 4 out of 14 in 1902, 3 out of 19 in 1903, 4 out of 26 in 1904, and 3 out of 23 in 1905.

Taking china and earthenware alone, there were reported to the Home Office the following number of cases during the last eight years:—

1906.	1905.	1904.	1903.	1902.	1901.	1900.	1899.
107	84	106	97	87	106	200	249

While the preceding tables show an improvement in the health of persons employed in the manufacture of china and earthenware in 1906, compared with 1899, the number of cases of lead poisoning in the potteries is not only higher than it ought to be, but there has not been the declension in recent years that had been hoped for. By loyally carrying out the Special Rules employers and employed have certainly succeeded in reducing the amount of industrial lead poisoning, but what would give the greatest satisfaction to the public would be knowledge of the fact that the manufacturers themselves were taking greater scientific interest in their work, combined with an increased regard for the health of their workpeople, so that by the introduction of new methods their own regulations would always be in advance of those put forward by the Home Office. Instead of following, manufacturers should lead. This brings us to the much-debated question as to whether it is not possible to manufacture china and earthenware without the use of lead glazes.

Leadless Glaze

The use of leadless glazes has been consistently opposed by a large number of the manufacturers on the ground that without the presence of lead in the glaze they cannot get the depth and beauty of colouring which are so much admired. In the Thorpe-Oliver report it is shown that by far the largest proportion of earthenware can be made without lead in the glaze, and that even where special colours are required and the demand for lead insisted upon, a smaller percentage of lead than that hitherto in use is sufficient. An exhibition of leadless glazed pottery was recently held in Westminster House. Those who had the opportunity of inspecting the various products could not be but impressed by the high-class character of the goods exhibited, and by the variety, depth, and beauty of the colouring displayed. It is true that leadless glazed ware is more apt to go wrong in the firing, and that at present it is more expensive to produce, but these are trade and economic problems which manufacturers would readily overcome if there was the stimulus of an increasing demand for the goods.

Manufacturers will only make what they can sell. Since all sanitary and office goods can be produced just as well without lead as with it, public bodies should set the example in their contracts of asking for leadless glazed ware, and if this were done an increasing public demand for domestic ware similarly prepared would end in creating, through the spirit of competition aroused, a supply that would prove just as satisfactory as lead glazed ware. The greater use of leadless glazes would obviate much human suffering. If manufacturers have hitherto been slow in moving in this matter on the lines indicated above, now that industrial lead poisoning has been scheduled for compensation under the Workmen's Compensation Act this circumstance may force them to reconsider the subject and to approach it from fresh standpoints.

The principal objections to leadless glazed ware advanced by manufacturers are the increased cost of production and the unreliability of the ware in passing through the ovens. The goods are said to "craze" more readily, *i.e.*, for the glaze to become cracked, and this means a monetary loss which they cannot afford. The exhibition of leadless glazed pottery at Westminster House already referred to was at the time much decried by several of the manufacturers. It was said that it was unfair to expect them to produce at a greater cost leadless glazed ware, which ware, if glazed with lead, could be manufactured at a cheaper rate abroad, and introduced into and sold in this country at a lower figure than it could be made for at home To say nothing of competition in foreign markets, it would spell ruin, so it was said, to the home trade, especially as in other countries there were no restrictions as regards the use of lead in potteries. I question very much whether in France or Germany there has been anything like the amount of lead poisoning in potteries that there has been in Staffordshire. The subject of plumbism in potteries has, at any rate on the Continent, never become the acute and burning question it has been in this country owing partly to different methods of production. In England it is not that manufacturers cannot produce leadless glazed ware, for W. I.

Furnival,[1] research ceramist and consulting potter, says that, even from the manufacturers' evidence, the production of leadless glazed ware in "*whole ovenfuls exclusively* is in certain cases practicable." It is the absence of a demand for it on the part of the public, who are deterred from purchasing the ware by its higher price, that is to a large extent the reason why it is not manufactured. That leadless glazed ware has great durability is shown by antiquarian discoveries. Egyptian potters used a glaze composed of silicate of soda without lead, probably because the soil of Egypt, being rich in alkali, did not require the addition of lead. Brongniart, in speaking of the enamelled bricks found in the ruins of Babylon, which go back to not less than 522 B.C., tells us that chippings and scales of these ancient bricks, when examined in the laboratory at Sèvres by MM. Salvetat and Lenormant, were found to contain neither lead nor tin. In Assyrian and Persian pottery lead was frequently used, but for durability and colour they are not superior to other pottery in which no lead was employed in the glaze.

In addition to risks to health from lead poisoning, there are certain departments of china and earthenware manufacture that are dangerous from the dust that is created. The bronchial and pulmonary troubles thus caused are dealt with in the chapter devoted to lung diseases caused by dust. Here it is only necessary to say that, taking the death-rate from pulmonary consumption as 100 for agricultural labourers, that of potters for the same disease is 453; in other words, for every 2 agricultural labourers dying from consumption there perish 9 potters.

File Cutting

File cutting by hand is an unhealthy occupation. The death-rate of file-cutters from pulmonary phthisis and lead poisoning exceeds the mortality standard of ordinary occupied males by 90 per cent., and after 35 years of age it is still higher. The explanation of the unhealthy nature of the trade is not far to seek. The work is frequently carried on in small buildings in the rear of dwelling-houses and in

[1] "Leadless Decorative Tiles, Faience, and Mosaic," 1904, p. 19.

yards in which there is little circulation of air. In most of the workshops there is no ventilation. The floor is frequently the ordinary soil. Men and women work together, and overcrowding is common. In file cutting by hand the man or woman sits astride a "stock." In front of him is a stone block, into the centre of which a piece of steel bar called a "stiddy" is inserted, and on this "stiddy" is placed a piece of metallic lead which is called the "bed." When about to be cut, the file is strapped flat on the "bed." By means of a hammer and chisel fine lines are made upon the file, each line representing a blow from the hammer. As the hammer usually weighs from 7 to 9½ lbs., and on large files there may be as many as 3,800 lines, a considerable amount of muscular effort is exerted by the file-cutter in the course of the day. When one face of the file has been cut it is lifted from the bed, rubbed with charcoal or chalk, and then replaced, cut-face downwards, for the other side to be cut. There is a considerable quantity of dust given off when the file is rubbed with charcoal, also during the cutting of the file. In an examination of the dust collected from the rafters of a file-cutting shop there were found 2·64 grains of metallic lead; in dust taken from the top of a "stock" 14·82 and 22·28 grains per 100, and from the floor under the "stock" 2·63 and 4·37 grains per 100. The work is extremely dusty. File-cutters are notoriously wanting in personal cleanliness. To the practice of taking their food into the workshops, and of eating it there without washing, to the disagreeable habit of licking their fingers when at work so as to get a better grip of the chisel, also to bending down towards the "stiddy" when at work and thus inhaling the dust, must be attributed much of their ill-health. Although, in the dust given off, the lead is mostly in the metallic state, still there is always a certain amount of oxidation going on which renders the lead capable of absorption.

The men and women who follow this occupation soon become anæmic, and many of them suffer from colic. Paralysis of the extensor muscles of the fingers and wrists is frequently met with in file-cutters. This affects mostly the left hand, since it is by the muscles of this hand that the chisel

is grasped, and muscular strain and fatigue predispose to paralysis caused by lead. The hand that wields the hammer does not always escape, so that in many instances the paralysis is bilateral. Frequently in file-cutters lead poisoning assumes the chronic form, so that in persons following this trade the death-rate from kidney disease is unusually high. The number of cases of lead poisoning in file-cutters reported to the Home Office during the last few years has been as follows :—

	1906.	1905.	1904.	1903.	1902.	1901.	1900.	1899.
File cutting	15	12	20	24	27	46	40	41

In Sheffield alone, which is the principal seat of the file cutting industry, the number of cases of lead poisoning has been falling. In 1903 there were 18 cases; in 1904, 17; in 1905, 10; and in 1906, 9.

Since lead poisoning contributes so largely to the ill-health of file-cutters, various substitutes for the bed of metallic lead have been tried, but without success. File-making by machinery is replacing file-making by hand, and is becoming an important trade in Sheffield. In order to harden files it is customary to dip them into a bath of molten lead. The men who dip the files occasionally suffer from plumbism, due to the fumes of the molten metal, but this can be prevented by ventilation and hooding of the bath.

Diamond Cutting: Setting of Precious Stones

Diamond cutting is one of the old industries of Amsterdam. The market for diamonds is London, but the workshop is Amsterdam. A branch of the trade has sprung up in Antwerp. The men who follow the occupation are well paid; they are intelligent and well-educated. Many of them can make from £4 to £5 a week. The work requires considerable skill, and by demanding close attention it

imposes a good deal of strain upon the eyes. The number of men employed in Amsterdam in diamond cutting is 8,000. Many of the men suffer from lead poisoning. In my visit to one of the largest diamond cutting shops in Amsterdam, giving employment to 400 men, I was struck by the high temperature of the workrooms and the want of fresh air. The large number of gas jets in use explains the overheated condition of the workrooms, while to the sedentary nature of the work and enfeebled resistance to cold, as in nearly all indoor occupations, must be attributed the defective ventilation and dread of open windows.

In order to cut a diamond another diamond is required; hence the saying "diamond cut diamond." After this preliminary cutting the diamond is fixed in a mass of molten metal, about the size of a walnut, containing 60 per cent. of lead and 40 of tin, and the alloy is allowed to cool. Thus securely fixed in the metallic knob, the diamond is subsequently polished by hand or by an iron wheel rotating at the rate of 2,400 revolutions per minute. It is during the fixing of the diamond in the lead alloy and afterwards during the polishing processes that the workmen run the risk of becoming poisoned by lead. The skin of the fingers of the workmen is quite black through coming into contact with the hot metal and the varnishes used, but there is also a good deal of lead dust, probably in the form of lead oxide, floating in the atmosphere of the workroom, inhalation of which is one of the causes of plumbism. Nearly all of the men were extremely pale, and several of them showed the characteristic blue line on their gums. Some of the men had suffered from lead colic and a few of them from loss of power in the muscles of the hands and wrists. The subject of lead poisoning in diamond-cutters was recently taken up by the Dutch Government, and a prize of £500 was offered to any person who would find a reliable substitute for lead to hold the diamond during the polishing of the stone. No prize has as yet been awarded, but the Government is on the eve of making an important announcement in regard to this subject.

Setting and Polishing of Precious Stones

What has been said of diamond cutting applies with equal force to the cutting and polishing of other precious stones. The Medical Officer of Health of Reichenberg, Bohemia,[1] has drawn attention to the large number of cases of lead poisoning in the men employed in polishing precious stones in the workshops of Turnau and neighbourhood. There were 25 men suffering from lead colic and paralysis. These, however, were as nothing compared with those who made the cutting and polishing of gems a home industry. As a consequence of making their living-rooms their workshop and of sitting down to their meals without washing their hands and face, the men were pale, and nearly all of them exhibited a well-marked blue line on their gums. Their work consists in polishing garnets, and for polishing 60 dozen stones the men receive 50 kreutzer (4s. 8d.). The polishing is done on pieces of metallic lead which have from time to time to be remelted in the pot. The men are thus exposed both to the fumes of molten lead and to dust. It is stated that metallic lead is not absolutely necessary, and that in the technical school the fixing of the stones is done by means of copper and zinc. Notwithstanding this fact the workmen at their homes still adhere to the use of lead, and as a result there are many cases of lead colic and paralysis among garnet-polishers.

Plumbism is also met with in polishers of other kinds of gems and precious stones.

Enamelling of Iron Plates and Hollow Ware

The enamelling of iron plates and hollow ware is one of the industries of the "Black Country." It is carried on in Birmingham, Wolverhampton, and the immediate neighbourhood. Nearly all the large enamelled plates at railway stations announcing the name of the station, also the enamelled advertisements, are made in the districts just mentioned. The process of manufacture can be told in a few

[1] "Les Industries Insalubres," p. 91.

words. The iron plates are first cleaned, then smeared with a thin solution of gum and subsequently are powdered with metallic dust, or a liquid containing a metallic powder is allowed to trickle over them. The powder used often contains as much as 25 per cent. of a fritted lead compound; in other instances there may be no lead at all. Having received its first coating, the plate is placed in an oven and exposed to a high temperature. On its removal and after having become cooled it is swilled with water. The colours required are put on with brushes, and when this has been done the plate is laid upon hot pipes, moderately heated, to dry. Up to this stage all the work has been more or less wet and has not been dangerous to any great extent; besides, the lead compounds used have been fritted and are therefore less soluble. The alphabetical letters, words, and numbers, &c., that are to appear on the plate when finished are obtained by placing a stencil with all the letters cut out of it upon the plate, and by women and girls with brushes rubbing off the surface of the plate exposed through the cut letters of the stencil. During this process large quantities of dust are given off, and if down-draughts have not been provided the atmosphere of the workroom becomes so thick that it is impossible to see across the room, while the hair and clothing of the workers become covered with coloured dust. This dust contains varying quantities of lead, which is inhaled, and consequently induces lead poisoning in those exposed to it. I have known it cause death in young females by acute lead encephalopathy.

The stencilling of the plate is generally carried on over perforated tables with a strong down-draught, so that the dust is carried downwards and away from the workers, but unless care is taken to see that the aspiration is powerful enough the dust rises upwards towards the face of the worker.

After the plate has been stencilled it is again placed in the oven, and if additional letters or words have to appear upon the plate differently coloured from those first inscribed, a similar process to that just mentioned has again to be

gone through, viz., dusting, or sprinkling, drying, stencilling, rubbing-off, and firing. Red lead and other compounds of lead are largely used in enamelling, and these are, as already stated, often present in the powder or solution to the extent of 25 to 35 per cent. Formerly arsenic was used in the enamelling of iron plates, but as it was the cause of serious ill-health among the operatives it had to be abandoned.

No female under twenty years of age should be allowed to follow this occupation. Only healthy women should be employed, and then only after a medical examination. Periodical medical inspection of the workpeople, with improved methods of ventilation, has done much to reduce the number of cases of lead poisoning in the enamelling trade.

In the tinning and enamelling of hollow ware, which is an industry also confined to the "Black Country," the pot or saucepan to be tinned is first swilled with a mixture of dilute hydrochloric acid and zinc chloride. After it has thus been cleaned or prepared it is dipped in a bath of molten tin and lead, usually a mixture of 40 per cent. of metallic lead and 60 per cent. of tin, but as tin is the more expensive of the two metals the molten liquid frequently contains as much as 70 per cent. of lead and only 30 per cent. of tin. Ware dipped in this bath is sold at a lower price. Unless the metal-pot is hooded so as to remove the fumes, the man who dips the ware in the bath, if he is not cleanly and careful, may suffer from lead poisoning. On an average there are 18 cases of plumbism reported to the Home Office as occurring in this trade every year. Dippers who are intemperate are specially predisposed to lead poisoning. The risk of lead poisoning is not confined to the dipper of the hollow ware, but extends to the users of the pots and saucepans, and since it is the poorer working classes who purchase the cheaper ware, nominally *tinned* but really *leaded*, they suffer in health owing to eating food that has been cooked in the utensils, the lead in the tinned lining inside the vessel having been dissolved out in the act of cooking. In what is known as the white enamelling of iron hollow ware many manufacturers are now making use of leadless glaze. Occasionally the men

who manufacture the white enamelled alphabetical letters used for advertising purposes, and which are seen on shop windows and elsewhere, suffer from plumbism. During the acts of "brushing on" and "wooling off" large quantities of dust are evolved from the coloured powders used, and as these often contain large quantities of lead there is danger from inhalation of the dust.

Electrical Accumulator Works

Owing to the increasing demand for electricity for lighting and motor purposes, also for telegraphic and telephonic requirements, the manufacture of electric accumulators has become an important industry both at home and abroad. Although the employment of electricity in this country has much increased of late, it is small in proportion to what it is in Germany. In the manufacture of electric accumulators a paste made of red lead and sulphuric acid is rubbed into the openings of perforated metallic plates. Usually the workman wears indiarubber gloves, but these get thinned, torn, and worn out in time. In the act of mixing the red lead and sulphuric acid so as to make the required paste the workman becomes enveloped in dust. There is no reason why the litharge should not be lifted by some mechanical means and not by a scoop, nor why the mixing should not be done in a hermetically closed chamber with extracting draught. A few years ago the number of cases of lead poisoning in electrical accumulator works in Germany had risen so high that the Imperial Health Office directed an inquiry to be made into the conditions of labour in the works. New regulations were introduced, and since then plumbism has become less frequent. In Great Britain, notwithstanding the vigilance of the Home Office, the number of cases of lead poisoning in accumulator works continues to be higher than it ought to be, as the table on p. 176 shows.

Mr. Kellet, H.M. Inspector of Factories, states that nearly all the cases of lead poisoning in his district occurred in one electric accumulator works. It would appear that there is a tendency in this country to start accumulator works in

NOTIFICATION OF LEAD POISONING IN ELECTRICAL ACCUMULATOR WORKS

1906.	1905.	1904.	1903.	1902.	1901.	1900.	1899.
26	27	33	28	16	49	33	32

premises that are quite unsuitable for the purpose. The result is always unsatisfactory and dangerous from a health point of view. Before such work is begun the premises ought to be inspected by representatives of the Home Office, and not, as is too often the case, when damage to health has been done. In a large electric accumulator works in which the cases of lead poisoning had fallen from 24 in 1901 to 1 in 1905, Dr. Hugh Hughes, of Ashton, gives the following report of the 69 cases which had occurred in the factory during the 9 years from 1897–1905 :—

Mixers, pasters, and labourers	45	cases
Lead burners	16	"
Casters	5	"
Lead sawyers	2	"
Stoker	1	"

In the Report of the Chief Inspector of Factories for 1906, the occupations of the 26 persons attacked with plumbism in electric accumulator works are as follows :—

Pasters	7	cases
Lead burners	5	"
Casters	2	"
Packers and makers-up	9	"
Mixer	1	"

As no mention is made in the last table of the numbers employed in electric accumulator works in this country, I give the following as the experience of one of the large accumulator works in Germany in order to show what are the dangerous processes :—

Occupation.	Numbers employed.	Number of Cases of Lead Poisoning.	Percentage.
Casting	30	3	10·0
Pasting	30	9	30·0
Soldering	16	6	37·5
Trimming	30	4	13·3
Plumbing	30	9	30·0
Section building ...	60	5	8·3

Clearly the soldering, pasting, and plumbing are dangerous departments. Much of the plumbism is preventible. The men on commencing work for the first time should have the dangers and the risks of the employment clearly pointed out to them, also the advantages of personal cleanliness and the use of warm baths. If warm baths are to be taken—and my remarks apply to all factories in which lead is used—the opportunities of doing so must be provided at the works by the employers, who should supply plenty of soap and towels, and the time required for washing should count as time spent at work in the factory. The baths provided at a large number of British factories are a disgrace and not fit for men to go into. It is all very well to say that workmen engaged in lead processes should take baths, but I have seen bath places in British factories and paint shops into which no man with any self-respect could go, and until employers grasp this fact and provide proper accommodation, suitably heated, also towels and soap, they cannot expect workmen to loyally carry out the recommendation in regard to baths. At several of the large works in Germany which I have visited the bath-rooms form a separate part of the factory, are properly warmed, and are under the direction of a special attendant. Discipline, which is such a feature of all German life, may have something to do with the fact that there is no difficulty in getting the workmen to take the baths, but the excellent character of the baths is not without an attractive influence. In some works a patent soap, known as *akremnin*, is used. It is said to contain a sulphur compound which precipitates the lead

on the skin as lead sulphide. The case of the lead-poisoned stoker referred to in one of the previous tables is not without interest. He had been in the habit of breaking up the old red lead barrels and of burning the wood on the boiler fire. I have known of cases, too, in bakers who heated their ovens in this manner, also in workmen who were engaged in breaking up old railway carriages and burning the wood.

Printing: Type-founding, Type-setting, Linotyping

Linotyping is rapidly displacing printing by type set by hand. Printing by the old method is not a healthy occupation. The rooms are kept too hot and are badly ventilated. There is a higher death-rate from pulmonary phthisis among printers than in most indoor occupations, and plumbism is not unknown owing to the men handling the type and inhaling the dust that is given off. Type metal is an alloy of lead with $\frac{1}{4}$ to $\frac{1}{5}$ of antimony. The antimony is added to give hardness to the type. Occasionally tin and copper are added in small quantities.

Several years ago the opinion was expressed by two French physicians, Tanquerel and Pidoux, that there exists an antagonism between lead poisoning and tuberculosis, *i.e.*, that the one tends mutually to exclude the other. Experience does not confirm this statement. The high death-rate of file-cutters from tuberculous phthisis, who, as a class, suffer much from lead poisoning, is proof to the contrary. From recent annual reports of the Typographical Association and of the London Society of Compositors it would appear that there has been a slight increase in tuberculous disease over the corresponding rate for the whole country, so that it must be admitted that printers are more liable to tuberculous phthisis than men engaged in most other indoor trades. Lead poisoning, therefore, instead of excluding tuberculosis, predisposes to it. A few years ago Hirt showed that pulmonary phthisis is much more frequently met with among persons working in an atmosphere containing lead dust than in those exposed to the influence

of iron and copper. While workers in iron and copper supplied 12 per cent. of phthisical patients, lead workers contributed 21 per cent. Twenty years ago a French physician, Leudet, pointed out the rapid development of pulmonary phthisis in persons suffering from chronic lead poisoning. That plumbism reduces the vital resistance there is no doubt. Probably this is the only rôle that it plays in the development of tuberculosis, for in all the lead industries in which phthisis is met with in excess, other agents are co-operating, such as dust or bad air accompanied by high temperature and imperfect ventilation. It is certainly the case that pulmonary tuberculosis is oftener met with in lead than in coal and iron miners, but this is not due to the fact that the men are mining lead ore: it is the consequence of working under unfavourable conditions as regards ventilation, and of domestic and social conditions more or less accidental to lead mining. White lead workers do not die from tuberculosis in larger numbers than persons engaged in other trades, but file-cutters and printers show a high death-rate from this malady—the former as the result of dust and lead, the latter as the result of bad air and dust.

The number of cases of lead poisoning notified in printers in Great Britain during 1906 was 16, and for the previous seven years 19, 15, 13, 19, 23, 18, and 26 respectively. In the 16 cases for 1906 are included, according to Dr. T. M. Legge, 8 compositors, 3 stereotypers, 2 machine operators, and 1 typecaster. While of the 19 cases reported in the previous year there where 10 compositors, 3 of whom died, 1 was a stereotyper, 1 a linotype machinist, 1 a type assorter, and 1 a typecaster. It is the compositors who suffer most. Although the number of cases of lead poisoning among printers is not large, yet the symptoms are often severe. Paralysis is frequent, and the cerebral type of lead poisoning, which is the worst of all, is not unknown. To the fumes given off from the casting-pot or lino melting-pot must be attributed some of the cases of plumbism in printers, but it is impossible to exclude the dust caused by the abrasion of the metal in the compositor's box, also the possibility of absorption through the skin by

handling the type. The dust in printing-shops created during the wear and tear of type has been found to contain as much as 14 per cent. of lead, and it is impossible to avoid inhaling some of this dust. In Newcastle-upon-Tyne there has been during the last few years a marked declension in the number of cases of plumbism in printers. There is nothing like the amount of lead colic and paralysis that prevailed a quarter of a century ago, and for this improvement in the health of printers new methods of printing must receive some of the credit. It is just possible that all cases of lead poisoning in printers are not recognised, for the presence of a blue line on the gums, which is of such useful help in the diagnosis of plumbism, is frequently absent in printers. In the Annual Report of the Principal Lady Inspector of Factories for 1906 attention is directed to the absence of a blue line on the gums in 32 women and female young persons engaged in printing, in several of whom there were other symptoms suggestive of lead poisoning. The absence of a blue line on the gums is a circumstance which ought to be borne in mind by medical men and confirmed or otherwise by experience.

It is undesirable that open metal-pots should be in a general room where type-casting, type-setting, and machinery are all at work. The pots should be hooded and have flues attached to them so as to carry away the fumes into the outside air, care being taken not to distribute the fumes too near the windows of dwelling-houses or workshops. In cleaning the flues the men should wear respirators, and, where possible, the dust should be kept sprayed with water. One cannot too strongly impress upon printers the necessity there is for having the workrooms well ventilated. In places where the ordinary hand type is used, the type should be cleaned by means of steam and boiled after usage. Printers should avoid eating with unwashed hands.

Printing by hand is on the decline. Stereotyping and linotyping are replacing it. The hurry of the age requires that newspapers should be printed quickly. There are several fast printing machines by which this can be done. By means of stamped cylinders, stereotyping makes it possible

to print without resorting to individual type. Rolls of paper miles in length feed the machines, so that thousands of newspapers can be thrown off in a very short space of time. Type-setting machines capable of automatically distributing the type, and the various forms of linotype machines, have certainly diminished the amount of lead poisoning in printers, but for finish and as a work of art it cannot be said that linotyped printing is equal to that done by hand.

Glass Polishing

Glass and crystal, when cut and made into the various products for which there is a market, have to be polished. This is usually done by means of revolving brushes running at high speed. Rouge or putty powder mixed with water is allowed to fall on the revolving brushes. Putty powder contains 28–29 per cent. of oxide of tin and 68–70 per cent. of oxide of lead, and as the revolving brushes run at great speed a good deal of spray is thrown off, which falls upon the clothes and hands of the workers and also upon the floors of the workroom. The liquid dries on the floor, and subsequently, owing to the traffic in the room, the putty powder rises into the atmosphere as fine dust and is inhaled by the workpeople. As to the harmful effects of putty powder on glass polishers I had abundant evidence when on the Dangerous Trades Committee of the Home Office. Several of the workers I examined had been obliged to give up work on account of paralysis of the hands and wrists, others had suffered from severe colic. A few deaths from saturnine encephalopathy were reported to us.

Various substitutes have been tried for rouge and putty powder, but as in some of the substituted powders Prof. Thorpe found arsenic to the extent of 0·13 per cent. estimated as arsenious acid, this was only replacing one poison in the powder for another and had, therefore, to be abandoned. The employment of harmless rouge powders should be encouraged by every possible means, and surely the resources of chemistry are equal to supplying something that will not poison the men. In France metastannic acid

powder has been found to be particularly serviceable. In the glass works at Baccarat it has been used for the last fifteen years with satisfactory results. Since in England the putty powder has been made containing smaller quantities of lead, the number of cases of plumbism has been fewer, but part of this is due to improved methods of polishing, better aspiration, and greater cleanliness on the part of the workpeople.

Dye Works

In dye works where yellow colours are got from chromate of lead, the dust given off by the yarn is extremely injurious. The women who handle and pull the yarn become covered with yellow dust. They become anæmic and complain of severe headache. Many of them have sharp attacks of colic, while in others the more serious forms of nerve disorders are met with. In a dye works in which during the cold weather the running of the ventilating fan was stopped, there occurred quite an outbreak of lead poisoning—one of the young women unfortunately died from acute plumbism. On restarting the fan the health of the operatives again improved. Means should be provided in all dye works for the withdrawal of the dust away from the workers; the women should wear overalls and caps, otherwise their hair becomes covered with yellow dust.

In calico printing lead poisoning sometimes occurs owing to the printing of colours on the cotton cloth by means of lead salts. The danger is met with in the drying-rooms, and is due to the inhalation of the dust given off during handling of the dried goods.

House, Coach, and Ship Painting

Painters are extremely liable to suffer from lead poisoning, especially if working in close and confined spaces. They become affected by inhaling dust during the sandpapering of surfaces, the stithe given off during the burning-off of old paint, also by absorption through the skin, especially if it is cracked. Freshly painted surfaces give off emanations which

are harmful to many persons. Some writers regard these emanations as hurtful owing to the turpentine with which the paint is mixed, but experience and experiment show that they contain traces of lead. If metal boxes freshly painted with white lead are placed in a glass jar, and the air aspirated from the boxes is carried through a 10 per cent. solution of sulphuric acid, traces of lead are invariably found. It is only a trace of lead that is found, for by the delicate test discovered by Professor Trillat, of the Pasteur Institute, Paris the presence of the metal can be proved. An acetic acid solution of tetramethylate of diphenylmethane gives a beautiful blue colour with binoxide of lead. This test will demonstrate the presence of one three-millionth part of lead so long as steps have been taken to convert the lead previously into binoxide by oxidising the lead salt by an alkaline hypochlorite solution. To such emanations, therefore, as are given off from a freshly painted surface part of the lead poisoning of painters must be due. Until recently we did not know for certain in what form the lead is present in the emanations, *i.e.*, whether molecular or as vapour. Animals that have been placed in freshly painted chambers and muzzled so as to obviate all chance of licking the surface or of eating the paint suffer from colic, and men and women who have slept in freshly painted rooms have presented symptoms of lead poisoning.

I have recently been consulted by a house-painter who had been suffering off and on from lead colic, but who has latterly become very ill, especially after mixing the white lead with oil to make paint and also after using the paint. The mixture emitted such a disagreeable odour that he frequently vomited after using it. On some occasions it was so disagreeable that he could not go near the paint. The oil mixture without the white lead had not an agreeable odour, but this was as nothing compared with that emitted by the paint. The man's illness was the result of the inhalation of vapours given off from the paint. He would begin the day's work feeling quite well, but as the day went on headache developed, and before leaving his shift he would vomit and feel extremely ill. It was not the turpentine in

the oil that made him ill, for the oil and turpentine mixture alone did not upset him. Evidently some peculiar compound is formed between the terebinthated oil and the white lead, inhalation of which is the cause of the symptoms of poisoning observed in painters. That such emanations from freshly painted surfaces occur has been proved by the experiments of MM. Heim and Hébert, also by M. Trillat, of the Pasteur Institute.[1] Heim and Hébert exposed cultures of a mould—*Penicillium glaucum*—to air in closed bell-jars under different conditions, viz., (*a*) air alone; (*b*) air which might become infected from dry white lead; and (*c*) air in contact with fresh paint. In (*a*) the mould developed by the third day, in (*b*) shortly after the third day, while in (*c*) the delay was considerable, and only a few colonies of growth appeared. In another experiment, the growth of a different mould—*Aspergillus niger*—was arrested by emanations from a mixture of lead and oil. In another series of experiments, Trillat found that dry white lead gave forth no emanations to check the growth of cultures, nor did the oil mixture which was used for grinding the white lead, but the fully completed paint checked growth. Emanations from paint are harmful to vegetable organisms, and experience shows that they are also harmful to human beings. A guinea-pig placed in a large bell-jar, the air of which had passed over freshly prepared paint, died eighteen hours afterwards, and in the lungs there were signs of acute congestion. While turpentine is itself toxic and may contribute to the production of some of the symptoms—headache, lassitude, and sickness—experienced by persons sleeping in freshly painted rooms, additional experiments by Trillat showed that when the paint was made with zinc oxide instead of white lead, although the same amount of turpentine was present, the animal took no harm. There is some peculiar combination formed at the time between the white lead and oil mixture, inhalation of which is dangerous.

Every year several deaths are reported among painters from plumbism. As notification of cases of lead poisoning in house-painters "is not obligatory," it is difficult to

[1] *Le Journal Officiel*, 4 Août, 1907, p. 786.

obtain satisfactory data in regard to the amount of plumbism in the trade. Sooner or later compulsory notification of all cases of industrial lead poisoning instead of, as at present, only those trades which come under the influence of the Factory Acts, will have to be made to the Home Office. Although not obligatory, 181 cases of lead poisoning in house-painters and plumbers were reported to the Home Office in 1906, including 36 deaths, compared with 163 cases for the previous year, including 28 deaths. A special form summarising the information under the Factory Act, 1901, which requires notification of industrial poisoning by medical practitioners, has been issued by the Home Office, and while the need for keeping the matter before medical practitioners will probably be lessened by the inclusion of certain notifiable industrial diseases mentioned in the third schedule of the Workmen's Compensation Act which came into force on July 1, 1907, upon the certifying surgeon will be laid the important duty of certifying whether a workman is suffering from a disease mentioned in the schedule, for on the "granting or withholding of such certificate depends (subject to appeal to a medical referee) the power of the workman to claim compensation," "as if the disease . . . were a personal injury by accident arising out of and in the course of that employment." The fact that the Workmen's Compensation Act has come into force in no way removes the obligation imposed upon medical men of notifying to the Chief Inspector of Factories cases of industrial lead poisoning.

The processes of house painting which are unhealthy are the burning-off of old paint and, after the prime colours have been laid on and the puttying done with white lead, the smoothing of the flat surfaces by means of sandpaper. Fume and dust are to be avoided, and in washing off old paintings by means of caustic potash care must be taken that the skin of the workman's hands is not cracked. House-painters should not hold in the palm of their left hand white paint for laying on surfaces by means of a palette knife. If there are cracks in the skin there is the risk of absorption. In one house-painter I found several small inflammatory indurations under

the finger-nails. Painters suffer more from "lead gout" in London and the South of England than they do in the North.

In *L'Echo Médical du Nord*, September 9, 1906, Dr. D. Verhaeghe gives an interesting account of an inquiry made into the health of the house-painters of Lille. Of 131 house-painters he found 68 to be in good health, 45 in fair health, and 18 in bad health. The period of life during which the men seemed to ail most was between 30 and 35 years of age.

There was a close correspondence between the ages of the men and the length of time they had worked at the trade. An attempt has been made by some French writers to explain the symptoms of lead poisoning in house-painters by their excessive use of alcohol. Far from underrating the prejudicial influence of alcohol in precipitating a patient into plumbism I have always maintained that it aggravates the illness, but it cannot in any way be regarded as the cause of plumbism, nor is it quite true that house-painters are a more intemperate class than other workmen, although 27 per cent. of the painters in Lille admitted that they took alcohol. It is not stated that they took it to excess. More than one-half of the workmen suffered from colic and digestive troubles. The few workmen who pass the age of 50 are men who have been careful in their habits and cleanly in their person. Before they reach the age of 50 the intemperate men are weeded out. Of the 131 house-painters examined, 90 supplied information concerning their families. Between them these 90 painters had had 467 children. Of those 107 had been stillborn and 93 died under 2 years of age, *i.e.*, among painters the still-births formed 22·9 per cent. of the births, while for Lille generally the still-born children only formed 8·2 per cent. Verhaeghe supplies statistics comparing the number of still-births before the fathers adopted house painting as a profession and after having done so, and he found that before the fathers became house-painters the still-births formed 6·66 per cent. of the births, and afterwards 21·05 per cent. In Lille, house painting is apparently not so organised a trade as it is in this country, where the men go to it as apprentices and few leave it to change into another trade; but taking Verhaeghe's facts as they are, they point in an

unmistakable manner to the occupation of the father exercising a baneful influence upon the life of his progeny.

The mixing of paints and colours is equally an unhealthy occupation, unless means are taken to obviate dust. The grinding and mixing of paints and colours, which are admitted to be dusty occupations, accounted for 27 cases of lead poisoning in 1906. On July 9, 1906, Draft Regulations for the Paint and Colour Trades were issued from the Home Office. These deal with the mixing, grinding in oil, and sifting of dry lead colours and the provision of exhaust draughts to carry away dust, monthly medical examination of the workpeople, the insertion in a Health Register kept in the factory of the names of all workers in lead processes, wearing of overalls and washing of the same once a week, provision of washing conveniences, and the prohibition of the employment of women and young persons in the manipulation of lead colours in the dry state or in the grinding of the colours in oil. It is anticipated that much good will follow adhesion to the Regulations.

Coach painting is often carried on in confined spaces. A well-finished coach will frequently have received as many as eighteen coats of paint before the varnish is applied. The colours sometimes contain large quantities of lead; so, too, do the "driers." Coach-painters become the subjects of lead poisoning by inhaling the dust when smoothing painted surfaces with sandpaper. I had recently a coach painter under my care suffering from double wrist-drop, who had become poisoned by painting iron coach frames before they had become quite cool. For the last eight years the following has been the number of cases of lead poisoning in coachmakers notified to the Home Office. In 1906, 85 cases, and for the previous seven years 56, 49, 74, 63, 65, 70, and 65 respectively. The notifications for the year 1906 show a considerable increase over those of the year 1905: 32 of the cases occurred in railway carriage and wagon works, 10 in motor-car works and 43 in coach and carriage works throughout the country. Part of the increase in the number of cases of plumbism in coach-painters is due to the prosperity of the motor-car industry, and is the result of inhalation of the dust evolved during

the sandpapering of the dried coats of paint. Painters of perambulators and men employed in making and painting railway signals are liable to plumbism.

Substitutes for White Lead

Recognising the harmfulness of white lead, many efforts have been made, both at home and abroad, to replace it by other pigments. When sitting on the White Lead Commission it was one of the subjects to which we gave particular attention. Several inquiries were made, but we found that among house-painters there was no such unanimity of opinion as called for a specific recommendation from us as to the use of white lead for external purposes. As regards internal decoration, opinions were more in agreement that zinc white could replace lead carbonate. A paint to have commercial value must have good covering power and durability; it must be capable of mixing well with oil, and above all it must not be too expensive. All these properties are possessed to a high degree by white lead made by the Dutch process, and they are only doubtfully possessed by zinc white, for although mixing well with oil and possessing covering power, it is, so far as outdoor decoration is concerned, not so durable, and is more apt to peel off.

White lead manufactured by the Dutch process is composed of small globules which mix well with oil, forming a soap, whereas most of the other pigments are crystalline and only make a mechanical mixture. One of the drawbacks urged against white lead is that it sometimes becomes yellow in the presence of sulphur in the atmosphere; hence for internal decorative purposes a mixture of lead carbonate and zinc white is recommended, since the lead gives covering power and durability and the zinc whiteness. In France the substitution of zinc white for lead carbonate has become almost a national question. Bill after Bill for the total suppression of white lead as a paint for buildings has been brought before the Chamber of Deputies and passed, but they have been negatived by the Senate.

It is interesting to know that as far back as 1775 Guyton

de Morveau, the distinguished rival of Lavoisier, suggested that zinc white should be substituted for white lead; in 1835 Léclaire demonstrated the comparative harmlessness from a health point of view of zinc white and its capability of replacing lead carbonate in the painting of buildings. When Lacrosse was the Minister of Public Works in Paris in 1849, he caused zinc white to be used instead of lead on Government buildings; in 1852 all the Préfets were circularised by M. Persigny, interdicting the use of lead, and in 1901 this was again done by M. Pierre Daudin. Not one of the injunctions issued has been of the slightest worth. During the last six years, owing to the large number of cases of plumbism in house-painters in France, an aggressive attitude has been assumed by many of the working painters, medical men, and legislators towards the use of white lead. It is difficult for any legislative body to interfere with an old-established trade. France certainly solved the problem of phosphorus necrosis in lucifer match making by substituting the sesquisulphide for the dangerous white phosphorus, but in regard to the use of lead paints *versus* zinc, opinions are still divided, and arguments are so well put forward by both sides that members of Parliament have a difficulty in coming to a determination as to the proper steps to be taken. In France there is a tendency to make all such industrial questions political, apart from their economic and social aspects. The Comité Consultatif d'Hygiène, a body to which problems relating to industrial hygiene are entrusted by the Government, reported in March, 1901, that the manufacture of white lead had become a much less harmful industry owing to the Expert-Besançon process of grinding and mixing the white lead in water, with the subsequent replacement of the water by oil as the paste passes on through the rollers, periodical medical examination of the workmen, alternation of employment, and the careful selection of workmen in the first instance, no intemperate man being received into the works. This is certainly true as far as it applies to the manufacture of white lead. As for the dangers from lead in house painting, the opinion has been expressed that the men were themselves contributory

factors to plumbism by their intemperance and want of personal cleanliness, but all painters who suffer from plumbism can scarcely be regarded as intemperate men.

To assist in settling the question as to whether zinc white can replace lead in painting the exterior of buildings, the results of many experiments have been made public in France: these are, it is needless to say, *pro* and *con*. Mention must be made of the experiments carried out by M. Livache under the direction of the Society of Public Health and the Pasteur Institute. He states that at the end of three years, notwithstanding the objections of architects and white lead manufacturers, it must be admitted that the coatings of zinc exposed to the external atmosphere and to all kinds of weather have lasted as well as those of lead. A committee presided over by M. Rigolot and appointed by a syndicate of the master painters has watched the outside walls of the Pasteur Institute, and has certified as to the equal resistance of the coatings of paint made by white lead and zinc oxide during the years 1903, 1904, and 1905. In consequence of this report the Minister of Public Works sought the opinion of the principal engineers of roads and bridges all over France. Of the 107 reports received, 73 support the opinion of the equal resistance of zinc and lead both for the interior and exterior of buildings. Zinc white is the more expensive, but M. Livache states that the increased cost only amounts to 3 fr. 60 c. in the three coatings over a surface of 100 metres, *i.e.*, over a little more than 300 yards, and that by the addition of a small quantity of sulphate of barium to give body to the paint the cost is not greater than white lead. It is only right that I should interpose here the remark that in Great Britain sulphate of barium, owing to its crystalline nature, finds little acceptance with house-painters. The interdiction of white lead in France is not yet an accomplished fact. The Chamber of Deputies has on at least two occasions voted in favour of the total prohibition of lead, and it remains to be seen what action the Senate will again take in the matter. In the French experiments zinc white apparently withstood exposure to the weather to the satisfaction of the experts, but whether

in the more trying climate of Great Britain it would have enduring powers equal to white lead is still not proven. My own opinion in regard to the subject, which is based upon the experience gained when a member of the White Lead Commission, is that white lead is superior to zinc as a paint for the exterior of buildings, but that for internal decoration zinc white gives as good results as lead. The opinion of many coach-painters is similar to my own. Experience has convinced them that for the interior decoration of railway carriages and for van-building zinc white is just as satisfactory as white lead. In the manufacture, too, of cornice poles and rings white lead is being discontinued, reliable substitutes having been found in zinc white and in a substance known in the trade as "lithopone."

Minor Industries in which Lead is Employed

It would be impossible to enumerate all the industries in which lead in one form or another is employed and in which plumbism may occur. Persons employed in making lead capsules and in fixing them upon the corks of bottles of beverages and proprietary medicines become occasionally the victims of plumbism. In persons employed in making measuring tapes for tailors, also in tailors' cutters, I have known lead poisoning occur through the men holding the tape in their mouth. The manufacture of masonic clothing is not free from risk to health. The machine girls who bind the white skin with ribbon to form the apron complain of the white dust that is given off. This dust frequently contains small quantities of white lead, inhalation of which explains the anæmia of the machine girls, the severe headache they suffer from, and the blue line observed on their gums. Lead poisoning is met with in persons employed in indiarubber works owing to the use of lead carbonate as a whitening agent, also in the painters of safes. It is not necessary to use lead paints for safes. Non-poisonous paints give equally satisfactory results. There has been within recent years a slight increase in the number of cases of lead poisoning in brass works, especially in the dressing of brass castings, and

due in all probability to lead forming a constituent of some of the compositions used in making brass. Men employed in the tempering of the spiral springs of railway buffers have occasionally suffered from plumbism. The springs are dipped in a bath of molten metal containing lead, and during the process of testing the springs in a machine called a "scragg," Mr. Dobson, H.M. Inspector of Factories, Sheffield, found that the men who were thus employed were specially liable to plumbism.

Symptomatology and Pathology of Lead Poisoning

While of all the industries which give rise to plumbism the manufacture of white lead is the most important, there are others which do not rank far behind it so far as ill-health of the workpeople is concerned. No matter how plumbism is induced, whether by inhalation of dust, absorption through the skin, or swallowing of soluble lead-salts, the symptoms are the same. One of the principal things to bear in mind is that it is the continuous entrance of very minute traces of lead into the body rather than the occasional entrance of a larger dose that induces the most severe forms of plumbism, for it is of the nature of lead to act slowly, and thus gradually to undermine the health. One of the earliest symptoms is colic, but for some time previous to the onset of abdominal pain it will be found on inquiry that the patient on getting up in the morning had experienced a disagreeable metallic taste in the mouth which prevented him enjoying his breakfast, that he felt headachy and rather sick. His features, too, had been altering, for his face had been gradually becoming paler and more expressionless. To the peculiar pallor of the face and the appearance of the features generally the term "saturnine cachexia" is applied. The increasing pallor of the face is associated with a degree of bloodlessness which tends to become worse. After a few weeks' exposure to lead in a white-lead factory I have seen young healthy women not only lose their ruddy appearance and become quickly pale, but die from saturnine encephalopathy within four months of taking up the work. Some persons are more

predisposed to plumbism than others, but no one is immune. There is both a personal and a family idiosyncrasy to lead poisoning. People who are naturally pale and anæmic, who cannot eat well or who are intemperate in the use of alcohol, are more liable to plumbism than others. Poverty and its accompaniments predispose to it, so does the absence of personal cleanliness. Young adults are more liable to lead poisoning than men and women of maturer age. Females, in my opinion, are not only more susceptible than males, but in them the malady is more apt to assume the worst form, viz., the cerebral type, or what is called lead or saturnine encephalopathy.

After having experienced headache for days or weeks, and perhaps having suffered from constipation, the patient is seized, often rather suddenly, with severe pain in the abdomen, in the neighbourhood of the navel, attended by vomiting and usually accompanied by constipation. The pain is not due to constipation, for it does not disappear when the bowels have been freely moved, and besides, instead of constipation there may be diarrhœa. So severe in some instances is the colic that it is difficult to restrain the patient. The pains come and go, and are therefore paroxysmal in character, or they are more constant and are so severe that the patient writhes in agony. Occasionally he gets relief by the external application of warmth and gentle pressure, in other instances the patient cannot bear to have the abdomen touched. The pain is of two kinds. There is a superficial and there is a deep-seated pain, either of which may continue for two or three days, but gradually becoming less. Once the extreme acuteness of the pain has subsided, it is usually found that the pain, as tested by pressure of the examiner's hand, is worse on one side of the abdomen than the other, and that pressure along the course of the pneumogastric nerve in the neck is always more painful on the same side as that on which the abdominal pain is more severe. When the abdominal pain is superficial it is usually paroxysmal and aggravated by pressure: on the other hand, when the pain is more deeply situated, it is more constant, and is rather of the nature of a dull aching than acute pain. The belly, as a

rule, is retracted. The pupils are frequently unequal. The pupil of the eye of the same side as that on which the abdominal pain as elicited by pressure is the more severe is usually, but not invariably, the smaller of the two. The pulse at the wrists is unequal, that on the side of the abdomen which is the more affected being sometimes the stronger, sometimes the weaker of the two. While the abdominal pain persists the sulphocyanide of potassium disappears from the saliva, but on the subsidence of the colic there is a reappearance of the sulphocyanide in the saliva. The presence of this salt in the saliva is demonstrated by the development of a reddish-brown colour on the addition of a small quantity of a weak solution of Liquor Ferri Perchloridi to the saliva.

It is difficult to say what the colic is due to. In animals that have died from acute lead poisoning I have found the small intestine so firmly contracted in places by muscular spasm as to completely obliterate the calibre of the bowel. Spasm in all probability plays an important part in causing pain, but what is the cause of the spasm? It may be that lead primarily acts upon the nerve ganglia in the abdomen, or upon the small blood-vessels, and by causing them to contract shuts off some of the blood supply and thereby induces muscular spasm, or it may be that lead acts as a poison to the intestinal muscular fibre and by its direct action causes the small intestine to be constricted in some places and not in others. To this cramp-like contraction the colic is in all probability due.

Lead colic has sometimes been mistaken for appendicitis, also appendicitis wrongly diagnosed as lead colic, and patients exposed to the risk of a surgical operation when medicinal treatment would have sufficed. With the greatest care possible it is not always easy to differentiate between appendicitis and lead colic. The presence of a blue line on the gums is suggestive of saturnine poisoning, but a house-painter or any other person who is working in lead is just as liable to appendicitis as other people. The difficulty specially arises when the pain of lead colic is referred to the ileo-cæcal region, *i.e.*, low down in the right side of the abdomen.

Some physicians maintain that lead as a toxic agent is of itself capable of causing appendicitis, since perforating appendicitis has occurred in plumbism. In cases of obscure abdominal pain the cause of which is not clear, or where a history of lead is obtainable, an opinion should not be given until after very careful examination of the patient and due consideration of all the facts bearing upon the illness. A slow pulse, absence of fever, vomiting and a diminished area of hepatic dulness point to lead colic as against appendicitis. The location of pain in the neighbourhood of the umbilicus is in favour of plumbism. Although this is the usual seat of the pain in lead colic, the pain may not remain confined to this spot but radiate pretty well all over the abdomen. The co-existence of vagal pain in the neck, brought out by pressure, would confirm the suspicion of the abdominal pain being due to lead colic. In the abdominal type of lead poisoning, colic, vomiting and constipation are usually present together, and these three symptoms constitute the saturnine triad. During the height of the pain the radial pulse often becomes so small as to be almost imperceptible; in other instances it is hard and resistant. The pulse frequently falls as low as forty to the minute. It is seldom that patients die during an attack of lead colic.

As an indication of the difficulty of making a diagnosis in the acute abdominal illness of a lead worker, let me mention the following. A man about fifty years of age, but who looked much older, a lead worker, was admitted into the Newcastle Royal Infirmary under my care, suffering from fæcal vomiting, a dry parched tongue, and constipation. He was sent into the Infirmary under the care of a surgical colleague for operation, as the man was supposed to be suffering from intestinal obstruction. As the patient was extremely ill and in a state of collapse, operation was deferred. When seen by me on the following day there were the symptoms already mentioned, and with these there was present a well-marked blue line on the gums. The vomiting continued, and as no urine had been passed for two days a catheter was passed into the bladder and a small quantity of urine removed. This contained albumen. The diagnosis

of uræmia was made and the vomiting was regarded as due to kidney disease, such as is met with in chronic plumbism. As the urinary secretion was never re-established the patient died a few days after his admission into the Infirmary, and at the post-mortem examination the kidneys were found to be extremely contracted and the seat of marked interstitial change. The case, therefore, was one of uræmia occurring in a lead worker and simulating intestinal obstruction.

On the gums of a patient suffering from plumbism there is usually observed a blue line along the margin of the gums close to the teeth, better marked, as a rule, on the lower than on the upper gum. This line, known as Burton's line, may be present when all the teeth are in excellent condition, although in many lead workers usually several of the teeth are decayed and the gums ragged and slightly ulcerated. Where the teeth have fallen out or been extracted the blue line is at that particular spot often absent. The blue line is due to a deposit of lead in the form of sulphide in the deeper cells of the epidermis, and is the result of lead combining with sulphuretted hydrogen evolved from the decaying morsels of food between the teeth. In cases where the gum has ulcerated the dark particles of sulphide of lead are found in the large phagocytic cells, also in the fixed cells of the connective tissue of the gum. Now and again a large blue patch can be seen inside the cheek of a lead worker who has at the same time a well-marked blue line on his gums. The patch is generally opposite a decayed tooth. I have also found similar blue patches on the lower part of the small intestine and ascending colon of persons who have died from chronic lead poisoning. Occasionally, too, the upper surface of the tongue is stained blue. The presence of a blue line on the gums, although strong confirmatory evidence of plumbism, is no proof that the person at the time is suffering from lead poisoning, for on examining the gums of all the workmen in a lead factory nearly all of them will show a blue line. It only indicates that lead is deposited in that particular part of the system. When it is accompanied by other symptoms the blue line becomes a valuable sign.

Mention has been made of the peculiar pallor of the face in lead poisoning. This is due to anæmia. On examining the blood microscopically the red corpuscles are found to be fewer in number than in health. Instead of there being 5,000,000 red blood corpuscles per cmm. of blood, as there should be in health, there may be two-thirds or only one-half of the normal number. In one of my lead poisoned patients there were 2,700,000 coloured corpuscles and 10,000 white corpuscles. Accompanying this diminution in the number of the red blood corpuscles there is a corresponding fall in the amount of hæmoglobin or colouring matter of the blood. The white corpuscles are not increased. Gravitz has drawn attention to a peculiar structural change undergone by the red blood corpuscles and brought out by the use of special staining reagents. They exhibit a distinctly granular appearance, due to the minute granules taking on basic aniline stains. The white corpuscles do not usually show any profound structural change or percentage numerical alteration. In the case just referred to the colourless corpuscles were distributed as follows, viz.:—

		Lead Poisoning.	In Health.
Polymorphonuclear	...	66 per cent.	60–70 per cent.
Small lymphocytes	...	20 „	15–30 „
Large „	...	6 „	
Eosinophile cells ...	...	8 „	5 „

The eosinophile cells were slightly in excess. Occasionally a few nucleated red blood corpuscles are found in plumbism. The anæmia has been said to be proportional to the length of exposure to lead, but this is not always the case, for I have seen young women become markedly pale in a very short time. It is the function of the red blood corpuscles to absorb oxygen from the air in the lungs and to carry this gas into all the organs and tissues of the body. A deficiency in the number of these corpuscles implies imperfect oxygenation of the system, with all its consequences. Workers in lead may, as stated, become anæmic at an early date after exposure to lead: once it is developed the pallor remains for a long time, even after the patient's retirement

from the factory. Malassez, a French physician, although admitting that anæmia may rapidly develop, is of the opinion that the bloodlessness of lead workers is proportional to the length of time they have spent in the works. According to Malassez, the blood of a painter, which at the commencement of his occupation contains 4,500,000 red blood corpuscles, will after five years contain 3,700,000, at the end of twenty years 2,600,000, and at the end of thirty years 2,200,000 red corpuscles.

Lead as a poison strikes hard the blood-making powers of the body. It is probably by this fact and the recurrent demands made upon the system by menstruation that the greater susceptibility of women to plumbism is to be explained. The idiosyncrasy is not confined to women alone, for I find it present in the female sex of most animals. The menstrual flow is usually increased in female lead workers, but occasionally there is amenorrhœa. Women who are the subjects of plumbism even so slightly as not to present symptoms, exhibit when pregnant a marked tendency to abort. Several animals under my care have in experimental plumbism miscarried. Lead destroys the reproductive powers of both men and women, but its special influence upon women during pregnancy is the cause of a great destruction of human life. A large percentage of the children born to lead workers die within the first few months of life. The percentage of still-births is as high as miscarriages are frequent. In towns where the drinking-water has become contaminated by lead the tendency to miscarriage often assumes an epidemic form. With lead poisoned pregnant women who had been in the habit of miscarrying, I found that the only possible way for them to go to full term and have a living child was to get them to retire from the lead works altogether. Several women on my recommendation did this: they went into the country and took up work in the open air. While following a healthy occupation these women, after having frequently miscarried when working in lead factories, would have two or three living healthy children, but circumstances necessitating the return of these women to town, and

resumption of work in the lead factory, they in each successive pregnancy again miscarried. This loss of offspring is one of the most striking and appalling facts connected with lead poisoning and is beyond all controversy. A few cases taken from my note-book may be of interest. Mrs. H., aged 35, had 4 healthy children born at full time. She went to work in a white lead factory and was there for six years. During that period she had 9 miscarriages and no living child. Mrs. M., aged 30, has had 7 children and 3 miscarriages. All the miscarriages occurred after going to the lead works. Mrs. K., aged 34, had 4 children before going into the factory and 2 children after. She then had 6 miscarriages in succession, when she came under my care in the Royal Infirmary, having become the victim of plumbism and having lost the power in her arms and legs. She made a slow but good recovery and did not return to the lead works. In her next pregnancy she went to full term and gave birth to a living child.

Constantin Paul has published the results of 123 pregnancies where the father and mother had worked in lead. Of these, 64 ended in abortion, 4 were premature confinements, 5 were still-births, and 20 of the infants born alive died within the first year. In a series of cases amounting to 43 pregnancies in women who were working in lead he found 32 of these ended in miscarriage and 3 in still-births; 2 living children were born, but these were extremely ill-nourished. Malnutrition and mal-development of the offspring are striking features in infants when both parents are working in lead. The product of conception, even when retained until nearly full term, is not much more than half the normal weight of a healthy infant of the same period. Balland gives the details of 100 pregnancies where one or both parents were lead workers. Abortion occurred in 40 instances, 26 of the confinements were premature; of 32 of the accouchments that came off at term, 60 per cent. ended in still-births. Of the 40 children born alive, 26 died during their first year. Professor Lewin, of Berlin, mentions the fact of 4 women who worked in a factory where type for printing was made and polished. Among these women there were 15 preg-

nancies, but only one of the pregnancies ended in a live birth. He also mentions the case of a woman who at the age of twenty married a house-painter, and in course of time gave birth to a male child, who lived until four years of age. A year after this she entered a lead foundry. Until then her menstruation had been regular. Subsequently she became the subject of lead paralysis, both hands were affected, but although there was marked anæmia, there was, as is frequently the case in type-makers and printers, no blue line on the gums. During the eight years she worked in the foundry she had 8 miscarriages and only once a living child, who died five weeks after birth. It is an interesting fact that while a man who has suffered from plumbism takes a long time to recover, even after withdrawal from the lead works, a woman who has been a lead worker, and in whom during all the period she was in the factory each pregnancy ended in a miscarriage or a still-birth, will, if she gives up working in lead, probably go to the end of term in her next and succeeding pregnancies and give birth to healthy children who survive. The effects of lead in this particular direction are worst when both parents are affected, next when it is the mother alone who has been brought under the influence of lead; but there is evidence to show that lead impregnation of the male is also extremely prejudicial to the offspring. Rennert has attempted to express in statistical terms the varying degrees of gravity in the prognosis of cases in which at the moment of conception both parents are the subjects of lead poisoning, also where one alone is affected. The malign influence of lead is reflected upon the fœtus and on the continuation of the pregnancy 94 times out of 100 when both parents have been working in lead, 92 times when the mother alone is affected, and 63 times when it is the father alone who has worked in lead. Taking 7 healthy women who were married to lead workers, and in whom there was a total of 32 pregnancies, Lewin tells us that the results were as follows: 11 miscarriages, 1 still-birth, 8 children died within the first year after birth, 4 in the second year, 5 in the third, and 1 subsequent to this, leaving only 2 children out of 32 pregnancies as likely to live to manhood. In cases

where women have had a series of miscarriages so long as their husbands worked in lead, a change of industrial occupation on the part of the husbands restores to the wives normal child-bearing powers. How is it that lead exercises such a harmful influence upon reproduction? That lead has strong abortifacient powers the cases cited above amply indicate. It is knowledge of this circumstance that causes females of the lower ranks of life to resort in expecting motherhood to the use of diachylon pills (lead) for the purpose of inducing abortion, an ill-advised procedure and a dangerous line of treatment, since it has in too many instances caused the death of the woman herself. Lead causes abortion probably by acting upon the unstriped muscular fibre of the womb and inducing spasm. The poison also passes from the blood of the mother through the placenta to the fœtus in utero, and by killing the fœtus it thus indirectly brings about abortion. That lead passes thus from a woman to the offspring in her womb is confirmed by the detection of lead in the liver and nervous system of a still-born child upon whom I made an autopsy. The infant was the offspring of parents both of whom were white lead workers. The same remark applies to animals. In the dead fœtuses of some of my rabbits that had been fed with lead Professor Bedson on chemical analysis found traces of lead.

Following up this subject, the experiments of Balland are too valuable to be omitted. On one occasion I had the breast milk of a female lead worker who was nursing her infant examined for lead, but without success—probably because just at that time the woman was not actively engaged in the lead factory. Balland administered daily small quantities of lead to a bitch who on the day previous to the special feeding had given birth to seven puppies. These animals were entirely nourished by the mother's milk. For the first few days after commencing the lead all went well, then subsequently the puppies became anæmic, one or two of them seemed to suffer and become weak in their limbs and dwindled. Two of them were killed 25 days after their birth, and chemical analysis revealed the presence of lead in their viscera to the extent of 5 to 10 milligrammes in one

and 40 to 45 in the other. Balland's experiments clearly demonstrate the transmission of lead to the nursling through the mother's milk and the sad consequences which follow.

Mention has been made of the fact that the children of lead workers, if born alive, are frequently ill-nourished and die shortly after birth, and that this is particularly the case where the mother is the subject of lead toxæmia. Many of the children die in their first year from convulsions. Although lead destroys the offspring *in utero* and prevents pregnancy running its proper course, I have found, comparatively speaking, fewer instances of idiocy and imbecility in the children of lead workers than might have been anticipated. I have seen both cretinism and imbecility in infants in whom, as there could have been no possible influence of alcohol, and presumably none of syphilis, the occupation of one or other parent as a lead worker must have determined the imperfectly developed nervous system of the child. The large number of miscarriages and still-births and the short life that is meted out to the children of lead workers show that some peculiarly baneful influence had been stored up in the germ cell of the female and sperm cell of the male before impregnation, whereby in due course life is hit so hard in the earliest months of development that it cannot continue, for such is the blighting power of lead. Salpêtrière and Bicêtre are large hospitals in Paris set aside for the reception and treatment of nervous diseases. The experience of the physicians of these institutions is unrivalled. One of the physicians, M. Roques, speaking of the degenerates found in these hospitals, says that slowly induced lead poisoning on the part of both parents or in one or other of them is not only a cause of repeated abortions, high percentage of still-births and high death-rate of infants, but is the cause of convulsions, imbecility, and idiocy in many of the children who survive the first year of existence. Of 19 children born to parents who were lead workers, Rennert found that 1 child was still-born and that 17 were macrocephalic. In his studies upon hereditary degeneration and idiocy, Bourneville places house-painters in the unenviable first rank of the occupations followed by parents of mentally weak children.

Out of 87 cases relating to unhealthy trades, 51 were connected with white lead in some form or another, while syphilis was only responsible for 19. I am of the opinion that there is a larger amount of mental degeneracy in the children of lead workers in France than there is in Great Britain. It would seem, therefore, as if there were other contributory causes in operation than working in lead, but of these proof is difficult to obtain.

Lead acts directly and indirectly upon the kidneys, liver, and the nervous system. In old standing cases of plumbism the urine contains albumen and the kidneys after death are found to be contracted. Interstitial nephritis has therefore come to be regarded as the typical kidney lesion of plumbism, but in the early stages of the malady it is the epithelium of the tubules and the glomerular epithelium that are primarily affected. It is not uncommon to find albumen in the urine of persons who are suffering from their first or second attack of lead colic, and it may disappear on subsidence of the pain. In young women who have succumbed to saturnine encephalopathy a few months after having worked in a lead factory I have invariably found tubular nephritis, and the same holds good of animals to whom lead had been given in the food. Since in plumbism traces of lead are usually found in the urine, it is natural to suppose that lead, which is a foreign substance, on its elimination by the kidney would induce structural changes in these organs, and as the glomeruli and the epithelium of the tubules are the most sensitive parts, that these would suffer first. Albumen therefore may appear in the urine in plumbism under two different circumstances. It may be transitory and point to a curable condition, or it may be permanent and an indication of diseased kidneys. When the kidneys become affected there is frequently complaint of severe headache and loss of sight due to uræmic retinitis. It is to be remembered, however, that loss of vision may occur in lead workers without any indication of the kidneys being affected, also that lead is capable of lying latent in the body for a few years and then, unexpectedly and in a way difficult to explain, of giving rise to fresh symptoms of

poisoning. I have recently had a good illustration of this. A female patient, M. P., aged 36, was admitted into the Infirmary under my care owing to severe headache, paralysis of the muscles of one eyeball, and defective eyesight. She was a married woman, the mother of six children, one of whom died when young. She had also had three miscarriages. I recognised her as an old patient who before her marriage, while a white lead worker, had seventeen years previously been thrice under my care in the same ward on account of lead colic and ultimately saturnine encephalopathy followed by blindness, which persisted for several weeks. She made a good recovery, never returned to the lead works, but married a few years afterwards, and beyond having her family had enjoyed good health until shortly before her readmission into the Infirmary. Although the patient had not been brought during her married life under the influence of, or even into contact with, lead to her knowledge, she being the only one of the family who was ill, I took the view, in the absence of syphilis and other causes, that her headache and eye symptoms were the result of lead poisoning, and on a chemical examination of the urine being made by Professor Bedson, lead was found therein. As the most careful inquiry failed to elicit the possibility of any new source of poisoning, and under treatment all the symptoms improved, including the disappearance of lead from the urine, I cannot but regard the case as one of lead poisoning relit by the dissolution and reabsorption of the metal which had for seventeen years lain dormant in the tissues. This is the longest latent case of lead poisoning that I know of. Occasionally it has happened in patients suffering from obscure forms of paralysis that the administration of potassium iodide has been followed by the development of serious symptoms which ended in death, and which the data of a post-mortem examination and the facts obtained from relatives showed to have been due to chronic plumbism, that had not revealed itself by any symptoms until the advent of the paralysis. It remains to be seen how far the Workmen's Compensation Act can apply to cases of long latent lead poisoning. It is clear that the greatest care will have to be exercised both in pressing and opposing a claim.

Apart from causing albuminuria, plumbism alters the composition of the urine in other respects, so that in doubtful cases the suspicion of lead intoxication would be strengthened by detecting red or blue *indican* in the urine. To obtain the reaction equal quantities of a patient's urine and hydrochloric acid are mixed together, and to this a smaller quantity of chloroform is added and the test-tube shaken. If the chloroform becomes blue the urine contains indican or blue indigotine; should it become red, the colour is due to a product which is the outcome of the oxidation of indigotine, and is named indirubine. I have invariably found indican in the urine of patients suffering from lead poisoning, and while it is occasionally present in the urine of persons other than those suffering from plumbism, indicanuria in lead poisoning is so much more constant that it is of assistance in making a diagnosis when other symptoms and signs are deficient. The test is simple and is easy of application. The best proof that a patient is suffering from plumbism is the detection of lead in the urine on chemical analysis, but its absence is no proof of the contrary.

Lead is thrown out of the system in the fæces as well as by the urine. To Dr. Dixon Mann we are indebted for a full account of the elimination of lead by the intestinal canal. Several methods for the detection of lead in the urine are recommended; many of them are rather complicated, and can only be carried out satisfactorily in a chemical laboratory. It is not necessary for diagnostic purposes that a quantitative estimation should be made. A very simple method is to suspend in the urine a small bag containing calcium sulphide. If there is lead in the urine the sulphide of calcium will become blackened, owing to the formation of the black sulphide of lead.

The nervous system is peculiarly prone to be affected by lead. The most dangerous form of lead poisoning is that known as saturnine encephalopathy. Women are more liable to this form of acute poisoning than men. It is usually preceded by severe headache, when often without further warning the patient becomes convulsed and passes into a state of coma. Patients may die on the second or

third day without regaining consciousness. During the attack the urinary secretion may fall to as low as three or four ounces, and it may or may not contain albumen. Should the patient recover consciousness and live, it is occasionally observed that vision is lost. This loss of vision may be temporary or permanent. It was not an uncommon event when females were allowed to work in lead factories for most of those who suffered from saturnine encephalopathy to lose their sight permanently, and thus women still young in years would be found hopelessly blind and maimed for life. This brain type of lead poisoning may occur in patients without warning and without any of the usual prodromata, such as colic or loss of power in the wrists, and since it develops without the co-existence of albumen in the urine, it is clearly not due to uræmia and kidney disease, as some physicians maintain, but is the result either of the action of the lead itself upon the delicate nerve cells of the brain or indirectly of the lead having primarily interfered with the function of the excretory organs, and through this circumstance having produced a form of auto-intoxication. The opinion has been advanced that saturnine encephalopathy is the result of the combined action of lead and alcohol, a form of mixed toxæmia, but I have seen it occur in, and be the cause of death of, young females who had not taken stimulants at all. One of the earliest instances of this was a young female white lead worker who had only been in the factory five weeks and who had drawn only eight stoves. It occurs, too, in young women employed as dippers' assistants in potteries as early as six to eight months after taking up the occupation. M. Mosny, of the Hôpital St. Antoine, Paris, attributes the cerebral symptoms of lead encephalopathy to acute saturni-meningo encephalitis. On a few occasions I have seen saturnine encephalopathy preceded by seizures which had all the features of ordinary hysteria. A girl comes home from her work, and it is noticed by her friends that she is more excitable than usual. She is inclined to laugh or is disposed to cry, and is unable to control either her movements or her feelings. To her friends—and even to medical men who have not had

previous experience of such cases—the symptoms do not in any way appear to be serious, and yet within two days after the development of this toxic hysteria the patient will probably be dead. The lesson to be learnt is that we must never allow ourselves to be thrown off our guard by such hysterical symptoms, for they are often the prelude to saturnine encephalopathy, and therefore conceal a more profound poisoning of the higher brain centres than at first appears.

I have alluded to loss of eyesight. On examining the eyes there is evidence of neuro-retinitis with or without hæmorrhages. Some oculists have attributed the retinal changes to kidney disease, but as similar structural changes are met with in patients whose urine is free from albumen, all cases of blindness in lead poisoning do not own a kidney cause. The blindness may be due to changes in the optic disc and retina consequent upon kidney disease or to the direct action of lead upon the retina, but loss of sight in plumbism may occur without any structural alteration of the retina. Temporary loss of vision is occasionally complained of by patients during attacks of acute colic, and is to be explained by either the influence of the toxæmia or by the high arterial tension which may be present. Sometimes only one-half of the field of vision is lost.

The affection of the nervous system which occurs most frequently in lead poisoning is "wrist-drop." The muscles of the fingers, hands, and wrists become paralysed, so that the hands hang powerless by the side of the body, and the patient is in a pitiful plight, for he cannot work, much less feed or even dress himself. There is paralysis, more or less complete, of the extensor muscles of the wrists and fingers. Although both hands are affected, one hand—usually the one which has done more work—is worse than the other. Wrist-drop may develop rather suddenly, or it may come very gradually, preceded by slight pain in the muscles. Pain, however, is not a prominent symptom. The paralysis may involve the muscles of the forearm, also those of the calf of the leg. All the muscles that are affected become quickly atrophied. In adults lead has a special preference for the extensor muscles of the wrists and fingers, but in

children it is the muscles of the lower extremities that are affected, hence the greater frequency in children of ankle-drop, which is accompanied by loss of the plantar reflex, and is the counterpart of the wrist-drop met with in adults.

Wrist-drop and paralysis of the muscles of the upper extremities may occur in plumbism without there having been colic or complaint of headache. While it is the extensor muscles of the hand and wrist that are principally affected, the flexor muscles also become weak. Usually in wrist-drop the supinator longus muscle escapes, but when the loss of power involves also the muscles of the upper arm, the supinator longus is also found to be paralysed. In severe forms of lead poisoning the paralysis may involve the muscles of the lower extremities, also those of the trunk. Occasionally the muscles concerned in respiration become paralysed, and when this occurs death ensues. Symptoms suggesting general paralysis are sometimes observed: memory to a large extent is lost, the power of walking is impaired, and the ability to write is destroyed. The symptoms are preceded by delirium or by an epileptiform convulsion, after which it is noticed that the speech is defective. Notwithstanding the fact that under other circumstances these symptoms usually betoken a serious affection of the nervous system, the patient will, if the illness is due to lead, in most instances recover. It is this tendency of saturnine pseudo-general paralysis to undergo amelioration which differentiates it from the classic malady. All cases, however, do not recover. When death has taken place the appearances observed in the brain have been those of general paralysis, and on chemical examination of the brain traces of lead have been found therein.

Lead poisoning occasionally simulates *tabes dorsalis* or *locomotor ataxia*. There is incoordination of the muscles, attended sometimes by loss, sometimes by exaggeration, of the knee-jerk. Closure of the eyes so aggravates the muscular incoordination that the patient can hardly stand. In other instances the gait resembles that of a high-stepping horse, owing to weakness of the extensor muscles of the feet. Under proper treatment the patients usually recover.

Since the nervous symptoms in plumbism are widespread and varied, there has been considerable discussion as to whether the lesions are in the peripheral nerves and give rise to a neuritis or whether they are due to changes in the brain and spinal cord. On microscopical examination of the peripheral nerves in chronic lead paralysis there is observed a marked increase of the interstitial tissue, with atrophy of the nerve fibres, but the large cells in the anterior cornua of the spinal cord do not always escape. Although nerve cells are more easily affected by poisons than are nerve fibres, the latter, owing to their distance from the centres of nutrition in the spinal cord, may exhibit greater structural changes. The lesions in the peripheral nerves are due to changes in the cells of the spinal cord as well as to changes in the nerves. Gombault and Charcot consider that lead palsy is a peripheral neuritis only, and due to a segmentary and periaxial degeneration of the nerves. In this form of degeneration the axis cylinder of the nerve fibre is spared: the structural alteration is confined to a few of the segments of Ranvier, while the nerve fibres above and below the affected parts are healthy; hence the recovery of power which takes place in these cases. Occasionally in periaxial neuritis the axis cylinder undergoes fragmentation. Drs. Laslett and Warrington, of the Liverpool University Pathological Laboratories, have published the results of the microscopical examination of the nerves and muscles of the hands of a house-painter who had long suffered from wrist-drop. There was found marked atrophy of the posterior interosseous and ulnar nerves and a similar condition of the anterior roots of the sixth, seventh, and eighth spinal nerves, with a normal condition of the corresponding posterior roots. Ninety per cent. of the muscle fibres of the extensor muscles of the hand were atrophied, but still retained their cross striation; the connective tissue was increased, but the muscle spindles were unaltered. In the anterior cornual cells of the sixth and seventh segments of the spinal cord there were evidences of chromatolysis with excentral situation of the nucleus. While admitting that lead acts primarily upon the central nervous system, Laslett

and Warrington are of the opinion that in their patient the spinal cord lesion was secondary to the peripheral neuritis, and they base their opinion upon the excentral position of the nucleus. Adopting this view, the changes in the anterior cornual cells would not be the result of the action of lead upon the spinal cord, but would be consequent upon a lesion of the axis cylinders of the peripheral nerves; in other words, would be the result of a "reaction à distance," for a description of which we are indebted to Marinesco.

Asylum records show that lead poisoning may be a cause of insanity. Usually there are some premonitory symptoms, such as headache and toxic hysteria, or the patient appears as if he were intoxicated with alcohol. Sometimes symptoms of acute mania develop suddenly. The delirium is of a noisy character and the patient is with difficulty restrained. There may be intervals of quietude in which consciousness is fully restored. Delirium followed by coma and attended by a rising temperature marks a serious condition, from which the patient rarely, if ever, recovers.

There are many minor affections that lead gives rise to, *e.g.*, swollen and painful joints, painful swellings on tendons, enlargement of the submaxillary glands and testicles. The association of lead poisoning and gout has for many years been known, especially in the South of England. In the North we seldom find it.

When quite unexpectedly the death of a lead worker has taken place, no symptoms of plumbism, or next to none, having shown themselves during life, there may be found few, if any, naked-eye pathological lesions at the post-mortem examination of the body which will enable a physician to say that death has been the result of lead poisoning. The presence of a blue line on the gums should always be looked for; if found, it is confirmatory evidence. In acute saturnine encephalopathy the brain is sometimes shrunken and firm; the brain substance may be pale and firm or pale and œdematous as in uræmia. If there has been colic the small intestine may be contracted at places. Dark blue patches should be looked for on the mucous membrane of the large and lower part of the small intestine. In acute

plumbism the kidneys may be normal in size and on microscopical examination exhibit signs of tubular nephritis: in chronic plumbism, on the other hand, the kidneys are small and contracted, the capsule is firmly adherent, and on microscopical examination there are evidences of interstitial nephritis. To the naked eye the lungs, heart, liver, and spleen in acute plumbism often present nothing unusual, so that it is extremely difficult to say, in the absence of a history of the case, and of knowledge of the occupation of the deceased, a chemical examination of the brain and liver, and of any urine that may be present in the bladder, whether lead poisoning was or was not the cause of death. In old standing cases of plumbism the contracted kidneys, diseased arteries—rupture of which in the brain induces apoplexy—and the general malnutrition and pallor, all point to lead as the cause of the structural changes in the body; but since alcohol, other poisons, and other conditions induce similar pathological results, the post-mortem findings alone can, in the absence of a history of exposure, only suggest the probability of lead as the cause of death. On a chemical examination of the liver and brain being made, lead will probably be found in these organs if the case is one of plumbism. In the brain of one of my patients Professor Bedson found 0·634 grain of lead and 0·819 grain in the liver; in another female patient he found 0·779 grain of lead in the brain and 1 grain in the liver. One of the worst cases of acute lead encephalopathy that I have seen was with Dr. Inglis, of Hebburn-on-Tyne, in the person of a young woman patient who had been quite healthy and had only worked thirteen weeks in a white lead factory when she had convulsions, in which she died. In her brain no lead was found. Lead in some instances must enter into chemical combinations with the substance of the brain; lead-saturated cerebral cells would be incapable of performing normal function, but since death can occur without the slightest trace of lead being found in the brain after death, it would appear as if death under these circumstances was the result of a primary action of lead upon the eliminating organs, such as the liver and kidneys, causing destruction or diminution of

their function and a secondary toxæmia in consequence. Once lead is introduced into the human body the excretory organs do their best to immediately eliminate it. If minute quantities of lead are administered in food to animals, traces of lead will be found in the urine a day or two afterwards. It is when the eliminating organs fail to throw the poison freely out of the system that retention occurs and symptoms of ill-health show themselves. The lead passes out of the blood into the tissues, with which it may form insoluble organic compounds and lie dormant for a long time, years it may be, or the compounds are redissolved, so that in the absence of renewed exposure to the poison the patient becomes, *ab intra*, the subject of plumbism, and will probably be found passing lead in his urine.

The treatment of lead poisoning is preventive and curative. So far as the prevention of industrial lead poisoning is concerned, allusion has been made here and there in these pages to several of the means to be adopted. The Regulations issued by the Home Office for all kinds of lead factories are a great advance upon those of former years, and if loyally carried out will do much to reduce industrial plumbism. Work in the potteries is still being carried on under the Amended Rules published after the arbitration meeting at Stoke previously alluded to. There must be, however, no standing still as regards the Home Office and its supervision of the lead industries. Experience has frequently demonstrated that an increase in the number of cases of lead poisoning has been the result of carelessness on the part of the workers and non-observance of rules, laxity on the part of employers and foremen, and incomplete medical inspection. To fight successfully such an insidious foe as industrial lead poisoning there must be constant watchfulness by all concerned, also frequent revision and extension of Home Office Rules and Regulations.

Curative treatment concerns the individual. If the colic is not severe, rest in bed, application of external warmth, and the administration of a mild purgative, such as castor oil or magnesium sulphate, may be sufficient. Should the pain be accompanied by vomiting, draughts of warm alkaline water,

the administration of an effervescing soda and bismuth mixture, and washing out of the large bowel by means of an enema of warm water and olive oil, may be tried. When the pain in the abdomen is severe, relief may be obtained by a warm bath. To some patients it may be necessary to give a hypodermic injection of morphia, or of morphia and atropine combined. A mixture of magnesium sulphate and potassium iodide answers remarkably well, but in the treatment of some cases of plumbism the administration of potassium iodide must be made with care, since, as Melsens showed and my own experience confirms, the iodide may redissolve lead that has been lying inert in the body, cause its reabsorption into the blood, and thereby induce fresh symptoms of poisoning. Iodide of potassium is one of the best eliminants of lead. In cases where the symptoms have subsided but health has not been regained, the administration of the potassium salt will be followed by a reappearance of lead in the urine. I have known it cause albuminuria in chronic plumbism, which ceased with stoppage of administration of the drug. In cases where pain continues to linger in the abdomen and there is tenderness on pressure, I have found monosulphite of soda give great relief. Mild but lingering abdominal pain and paralysis quickly disappear under the administration of one-third to half a grain given every two hours. It is desirable in all circumstances to get the bowels moved. In due course, under the iodide and magnesium treatment, combined or not with Tinct. belladonna and carminatives, the symptoms of saturnine poisoning will subside, and perhaps no lead be found in the urine. Although free from lead, if the urine contains albumen and the phosphates are markedly diminished, it is more than likely that lead is still lying dormant in the tissues, for on administering iodide of potassium months afterwards lead may again reappear in the urine, the albumen may diminish or disappear, and the phosphates become increased. It is to this retention of lead in the tissues of the body and its redissolution and absorption that the development of fresh symptoms of lead poisoning must be attributed when occurring months after an apparent cure had been effected.

In chronic cases of plumbism, where the kidneys are affected

and the patient looks aged and his features altered, it is not always wise to give potassium iodide, but in recent cases of wrist-drop in young subjects the drug ought to be given combined with nux vomica and the administration of a saline in the morning. For paralysis, rest of the affected arm in splints with the daily application of massage and electricity will be found helpful. The constant current acts equally as well as the interrupted. Muscles which exhibit the reaction of degeneration, *i.e.*, which contract only to the direct application of the constant current, can be benefited by a course of induction coil currents. It is not a necessary requirement of electrical treatment that the responsive muscular contractions should be strong. There is the risk in over-stimulating weakened muscles of inducing fatigue. Dr. H. Lewis Jones, of St. Bartholomew's Hospital, recommends the electrical bath with the constant current in cases where it is sought to favour the electrolytic extraction of lead from the tissues. On the other hand, where electrical stimulation of the paralysed muscles is alone required, induction coil currents with or without a water bath are called for. The two methods differ in degree rather than in essence. The extraction of lead from the human body by means of electricity and the deposit of the metal in the form of chloride upon the electrolyte surrounding the body is more than a probable occurrence, and yet experimental evidence upon this point is not altogether free from error. Treatment of lead paralysis by electricity is both safe and useful. The use of the arm bath with the application of the sinusoidal current is very helpful in cases of wrist-drop. For more extensive lead paralysis, where, for example, the muscles of the legs are also affected a full-length bath with the use of direct and sinusoidal currents on alternate days is recommended by Dr. H. Lewis Jones as likely to "secure electrolytic effects as well as those of simple stimulation." Warm baths alone do good. For patients who are well off a visit to Bath, along with use of the thermal waters and electricity when there, is well worthy of a trial. Paralysis caused by lead is often slow to disappear, and for a time considerable muscular weakness is left behind, but in many cases the cure is quite complete.

It will fall to the lot of few medical men to treat cases of saturnine encephalopathy. During the convulsions the inhalation of a few drops of nitrite of amyl is of service. When the secretion of urine is scanty a hypodermic injection of pilocarpine is called for. Puncture of the lumbar region of the spinal canal and the withdrawal of one, two, or three ounces of clear fluid like water often relieves the cerebral pressure. Dr. Mosny, of the Hôpital St. Antoine, Paris, makes use of lumbar puncture not only as a curative measure, but also for diagnostic purposes. On centrifuging the clear fluid removed from the spinal canal by puncture between the second and third lumbar vertebræ, Dr. Mosny finds in it an excess of leucocytes, which he attributes to a reaction on the part of the cerebro-spinal membranes to the lead. In cases of acute lead colic in which I have punctured the spinal canal and drawn off one to two ounces of clear liquid like water, no trace of lead was found on submitting to chemical analysis the three or four samples, drawn from different patients.

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CHAPTER VIII

DISEASES DUE TO METALLIC POISONS, DUST, FUMES, ETC. (CONTINUED)

Other Forms of Metallic Poisoning

Arsenic

ARSENIC is used in the arts and manufacturers. Until recently it was extensively used as a colouring agent for wallpapers and artificial flowers. It is an ingredient of the "sheep dip" which is sold to kill tic in sheep. Workers in arsenic suffer from painful redness of the eyes and from eczema of the eyelids. More than a quarter of a century ago the Medical Society of London reported upon the unhealthiness of the trades in which arsenic was used. In the form of green arsenite of copper or Scheele's green it is used as a pigment. It is in this form, too, that it was added to wallpapers, in which it was often present to the extent of several grains per square yard, and as it is readily given off in the form of very fine dust, its presence in the air of a sleeping-room can be readily understood, and the ill-health of persons occupying these rooms just as readily explained. The symptoms complained of by persons occupying such rooms are headache, dryness of the throat, loss of appetite, mental irritability, depression, and loss of flesh. Men employed in the manufacture of Scheele's green have frequently painful ulcers on their fingers or on such concealed parts of the body as the groin and scrotum, where the dust has collected. Arsenic acts as an irritant to the skin, setting up eczema and ulceration: it is capable of

producing general poisoning as well. Five or six years ago there occurred in the Midlands an outbreak of arsenical poisoning, the result of drinking beer made from glucose which contained arsenic. Much suffering and ill-health followed. Many of the patients suffered from a painful affection of their limbs, neuritis followed by paralysis, dropsy of the limbs, and ulceration of the skin. Arsenical neuritis mainly affects the lower extremities, and in that respect differs from the paralysis caused by lead, which is mostly of the hands and fingers.

In visiting colour works I have seen ulcers on the hands of the workmen, but in the manufacture of white arsenic I have not noticed any serious ill-health among the employed. White arsenic is made in closed chambers. The only risk occurs during the packing of the finished product. The ill-health of the men employed at the reduction works of the arsenic mines near Tavistock, Cornwall, attracted a few years ago the attention of the Home Office, and was made the subject of an inquiry and a Report by Mr. Edward Gould, of the Home Office, and Mr. Joseph S. Martin, H.M. Inspector of Mines. Several of the smelters suffered from "arsenic pock," an irritation of the skin due to the action of very fine dust upon the perspiring skin; others suffered from bronchitis and respiratory troubles to a greater extent than the workmen engaged in other trades in the district. In the manufacture of the refined arsenic of commerce, the arsenic ore, or "mispickel," is first crushed between rollers, then sieved, and calcined in flat furnaces. The arsenic thus liberated from the ore passes from the furnaces to flues and chambers. These are cleared out and the arsenic soot, so called because it contains coal dust, is collected. This is again submitted to heat in a refining furnace, only anthracite coal and coke being used. The fumes given off settle as a fine white powder, which becomes, when ground, the white arsenic of commerce.

In the emptying of the flues respirators ought to be worn by the men, and no flue should be entered by the workmen until the temperature has come down to that of the surrounding media. The bronchitis which arsenic workers suffer from

has been attributed partly to the fumes given off by the raw material, which contains a good deal of sulphur. It is also the result of exposure to rapid changes of temperature.

Men when employed in removing vitriol solution from the depositing tanks in copper works occasionally suffer in consequence of the inhalation of arseniuretted hydrogen gas. The symptoms met with are dizziness and collapse, followed by jaundice and bleeding from the kidneys, attended by a rise of temperature.

An important point in connection with the subject we are discussing is that arsenic, whether taken as medicine, inhaled as dust or vapour, or applied externally to the skin, has apparently the effect, in some persons, of predisposing the tissues to growths of a cancerous nature. Workers in aniline colours which accidentally or otherwise contain small quantities of arsenic frequently exhibit patches of brown discolouration on their skin and mucous membrane, paralysis of certain muscles, and digestive troubles. Direct contact of the skin of the workpeople with arsenical compounds is a fruitful source of trouble. No matter the channel by which it gains entrance into the human body, arsenic is eliminated into the stomach and intestine, and in passing through the wall it induces marked hyperæmia, with symptoms of irritant poisoning, in the gastro-intestinal tract. The hands of the workmen should be free from cracks and sores. Gloves ought to be worn. If a man must work with his naked hands, all fissures and sores on the skin ought to be covered over by surgical collodion.

Arsenic is used in the curing of certain furs. Out of forty-two samples of furs recently examined by American chemists eleven were found to be heavily loaded with arsenic. The destructive effects of arsenic upon insect life are well known. Presumably, therefore, the arsenic is added to the furs as a preservative. The amount of arsenic found exceeded the one grain per square yard allowed by American law; it often reached 170 grains. The presence of such large quantities of arsenic in furs that are to be worn and in rugs for rooms is very dangerous. Occasionally it is found as a pigment in gloves and in textile materials.

Copper

Opinions are divided as to the harmful effects of copper upon the human body. That some of the workmen who are exposed to the fumes of the molten metal and to the metallic dust suffer from deranged digestion and troubles of the nervous system is only what might be expected; but there is never anything like the severe attacks of abdominal pain which are met with, for example, in lead smelters. I have known working shoemakers who were in the habit of putting brass nails in their mouth suffer a good deal from colic. A few copper workers have come under my care complaining of nervous depression, dizziness, and a staggering gait when walking. Metallic copper is less injurious than some of its compounds and alloys, such as brass. Symptoms of irritant intestinal derangement occasionally follow the ingestion of food cooked in copper utensils. In copper workers there can be frequently seen a greenish-blue line on the teeth, and the hair of the older workmen, which otherwise would be white, is quite green. Yet by none of these men is there complaint of feeling ill. On examining the hair under the microscope a thin layer of coloured material can be seen, composed of bluish-green crystals. These develop a deep blue colour on the addition of ammonia. By washing the hair in warm water the crystals are dissolved and the hair again resumes its normal colour, while in the water used for washing copper is found.

Although in copper ore, or what is known as copper pyrites, there is often a trace of arsenic, it is astonishing how free from symptoms are the copper smelters. I have visited the large copper-mines and smelting works at Kopperberg, in Sweden, and although the whole atmosphere reeks with the sulphur fumes given off during the roasting of the ore and the spire of the church and the roofs of the houses are coloured greenish-blue by the copper, yet the workpeople seemed to suffer no greater inconvenience than, and were just as healthy as, persons following other occupations elsewhere. What has been said of Kopperberg also applies to the smelting works at Swansea; although the vegetation in the

neighbourhood has been destroyed, the men who work at the furnaces enjoy good health. They are exposed to great changes of temperature, and are not always careful in regard to the use of alcoholic stimulants. In the cleaning out of the flues a great deal of dust is met with, and if the dust has not been previously watered there is apt to be illness among the men.

Brass

Brass is an alloy of zinc and copper. Birmingham is the home of this particular trade. During the pouring of the molten alloy into moulds the workroom becomes filled with dense white smoke, composed largely of oxide of zinc. The smoke, after hanging in the atmosphere for a time, ultimately settles down upon the rafters and ceilings of the workroom as a white incrustation. During foggy weather the atmosphere in these workshops is thick, and as many of these places are badly ventilated the men frequently suffer from headache, dryness of the throat, and a sense of general malaise. Digestive troubles, too, are often complained of, but the special malady from which these men suffer is what is called "brass-founders' ague," a misnomer, since it has no connection whatever with malarial fever, yet an illness attended by shivering, usually by feverishness and sweating, and accompanied by a feeling of exhaustion. Before the temperature rises, or in what corresponds to the cold stage, there is considerable languor, accompanied by a feeling of depression; the teeth chatter, and, as in the classical form of ague, there are headache and nausea. Occasionally the patient vomits, and obtains relief thereby. The indisposition, which usually lasts from one to two days, usually attacks men beginning work for the first time or who have been absent from it for a period. Owing to the dusty nature of the occupation, bronchitis and pulmonary phthisis are not unknown among the men. It is maintained, too, by some physicians that brass workers are more liable to affections of the nervous system than other workmen. The symptoms complained of by brass workers whom I have seen at the Newcastle Infirmary have been mostly on the side of the digestive organs, such as loss of appetite

distaste for food, a metallic taste in the mouth, obscure abdominal pains, constipation or diarrhœa, a sense of thirst and of dryness in the throat, without any visible signs of pharyngitis, also a degree of mental depression often amounting to hypochondriasis, and difficult to remove by medicinal treatment. The men become extremely nervous. When protruded the tongue is observed to be the seat of fibrillary tremor, and there is similar tremulousness of the muscles of the cheeks. It is difficult to say which of the two metals, zinc or copper, is the cause of "brass-founders' ague." The late Dr. Greenhow attributed the symptoms to the zinc. Dr. Hogben puts them down to the copper. It is more than probable that the symptoms are due to an admixture of the metals.

The necessity of personal cleanliness on the part of the workmen and of well ventilated workshops is apparent. Means ought to be provided for a ready escape of the fumes and for the removal of dust. The workshops ought to be cleaned at least once a year and the walls whitewashed. Hot and cold water should be provided for the men to wash in. The workmen themselves have found out by experience that milk is both a prophylactic or preventive as well as a curative agent. While the use of respirators seems called for, the men cannot work well in them. Women and persons under eighteen years of age are not allowed to work in the casting shop.

Zinc

It used to be thought that the fumes given off from pure zinc were not dangerous, but in the smelting of rude zinc ores which contain 1·6 per cent. of lead there is a certain amount of danger from plumbism, and in the similar treatment of *blende*, which is a sulphide of zinc and arsenic, the smelters occasionally suffer from the effects of arsenic. Dr. John Tatham's figures show that zinc workers have a higher mortality than the average workmen, viz., 1,198, as against 602 for the agriculturist, and that the death-rate in zinc workers has rather risen within the last decennium. The workmen are exposed to great heat. In men beyond the middle term of life the

mortality from pulmonary phthisis and respiratory diseases generally is more than double the standard figure. In my visits to the large zinc smelting works at Bleiberg, in Belgium, I could not find any evidence of ill-health among the workmen traceable to the zinc itself. Respiratory affections were common, owing to chilling of the body when in a state of perspiration, and rheumatic affections of the muscles and joints were also complained of. The dust from the furnaces is stated to be the cause of boils on the skin and of eczema, but these are met with in most industries in which the men are exposed to great heat and perspire freely in an atmosphere containing fumes. Schlockow, who has had large experience of the zinc miners and smelters of Silesia, states (*Deutsch. Med. Wochen.*, 1897, vol. v. p. 208) that in men who have followed the occupation for ten or twelve years there are frequently observed diseases of the nervous system. There is a loss of the sense of touch in the limbs, accompanied by burning sensations in the soles of the feet; the knee-jerks are exaggerated, the muscular sense is diminished and walking becomes unsteady, symptoms which Schlockow attributes to a lesion of the anterior columns of the spinal cord, but which other writers regard as due to a polyneuritis the result of lead poisoning. In Silesia the workmen suffer from laryngeal and bronchial catarrh as the result of dust, but tuberculosis is rare.

Zinc White or Zinc Oxide

Since zinc white has come to be regarded as a substitute for white lead for house painting, especially in France, there are sure to be in the future greater demands for this material. Zinc white is obtained by the oxidation of zinc vapours, the product being afterwards washed and dried. During the drying, sifting, and packing of the finished product dust is given off, but with ordinary care, such as good ventilation and the filling of the barrels in enclosed spaces provided with fans, the men employed do not appear to suffer any inconvenience beyond slight headache now and then. I did

not find that animals exposed to oxide of zinc in the form of dust, or who received it in their food over a length of time, showed signs of poisoning, but other writers state that dogs succumbed to albuminuria and glycosuria after having shown signs of nausea and disinclination for food, attended by anæmia and a distinct leucocytosis.

Men employed in printing upon zinc by means of chromic and phosphoric acids incur certain risks. These acids are applied by means of a sponge to clichés of zinc in order to remove all traces of fat so as to give more relief to the drawing. Phosphoric acid when employed alone causes no trouble, but it is not the same with chromic acid. This acid is a frequent source of abscesses and of erosions of the skin of the hands, arms, face, and neck. Some men are so susceptible to the action of chromic acid that they are obliged at an early date to give up the work. In one workshop one-sixth of the men had been off ill with abscesses, from which in some instances it took the men a fortnight to recover. India-rubber gloves have been recommended, but since experience has shown that the employment of these acids is not absolutely indispensable, and that a mixture containing only one of the acids in very small quantity gives equally good results and is free from danger, it would be better to adopt the newer method of printing than to rely upon gloves, the wearing of which can only protect the hands and forearms.

Mercury

Mercury, or quicksilver, is found in large quantities in Spain and California. It exists in nature in the form of cinnabar, a sulphide of mercury, from which it is obtained by simply roasting the ore, either alone or by mixing it with lime or iron filings. Mercury in the metallic form is thus given off and readily condenses. Workmen employed in the extraction of the metal frequently suffer from the mercurial vapour, which, quickly condensing, forms droplets that become deposited upon accessible mucous membranes and upon the beard and hair of the men. The metal rapidly becomes oxidised, and is thus rendered easy of absorption. Men

also become poisoned by handling the metal, for the skin becomes creased, and in the depths of the creases fine particles of the oxide of mercury become deposited. Mercury may be inhaled as vapour or as dust in the form of metallic salts. Men with open sores on their body ought not to be allowed to work in mercury. Formerly the metal was largely used in the silvering of mirrors. It was then a prolific source of ill-health among the workmen, but since the introduction of the new method of applying a solution of argentic nitrate to the glass and precipitating the silver by means of tartaric acid, the silvering of mirrors has ceased to be the unhealthy occupation it was in days gone by.

Mercury is used in the construction of barometers, thermometers, and instruments of scientific precision, while its salts, especially the nitrate, are used in felt hat making and fur dressing. One of the commonest symptoms of mercurial poisoning is ulceration of the gums attended by fetid breath and excessive salivation. Following closely upon these come muscular tremor and cachexia. In the process known as "carotting" or the brushing of rabbit skins with an acid solution of nitrate of mercury, the workmen lose the molar teeth of the upper and lower jaws. The remaining teeth become black and loose. Where the teeth have not fallen out they become eroded, owing to the action of the acid vapours.

The muscular tremor exhibited by workers in mercury has long been known as a symptom of poisoning. Years ago the amount of ill-health in the mercury miners at Almaden in Spain was so great that the mines had to be worked by convicts. These men not only worked but also lived, in the mines. They were not all cleanly in their habits, and as a consequence the mortality from mercurial poisoning was high. The few free men who were employed at the mines worked intermittently. In the intervals they followed agriculture or worked in their gardens. As these men were more cleanly in their habits they escaped much of the sickness, and on the whole had good health.

Although mercury is no longer employed in the silvering of mirrors it is still used in the arts and manufactures to such an extent as to be a source of considerable trouble and ill-health. It is greatly in demand for the separation of gold and silver from their respective ores by means of an amalgam; in sole stitching by American machinery; in the manufacture of incandescent lamps, in which mercurial pumps are used so as to create a vacuum; in water-gilding, where an amalgam of gold or silver, after having been applied to an object, is heated and the mercury driven off by heat, also in bronzing the interior of field-glasses.

In the extraction of gold from its ore mercury plays an important part. When the crushed auriferous soil has been subjected to several washings there remains a fine siliceous powder in which the gold is occasionally present in very small quantity, and in the form of too fine particles to be isolated by mechanical means. An attempt is therefore made to dissolve the gold in mercury until a rich amalgam is formed, from which the gold is separated by raising the temperature to 400° C. During the process, which aims also at the recovery of the mercury by condensation, the mercurial vapour escapes through the joints of the apparatus into the atmosphere, and as a consequence the workmen occasionally suffer in health. Metallurgists now find that in cyanide of potassium they have a good substitute for mercury, one that acts more easily and is attended by less risk to health than mercury. The cyanide process of dealing with gold ores has quite revolutionised the industry, and has made *reef* mining, which until lately was regarded as altogether a secondary source of gold, more important than *alluvial* and *placer* mining. It is an illustration of what can be done by the application of science to an industry that called for all the resources of chemistry. (*Vide* p. 236.)

Mercury volatilises at a low temperature. It is this circumstance which creates the danger, and explains the risks run by men working in a heated atmosphere containing the vapour given off by the metal. Many of the men

become pale and complain of headache and giddiness. The muscles of the face become tremulous; so, too, do those of the tongue, also the muscles of the limbs, especially those of the arms. The breath becomes fetid, the gums soft, swollen, and ulcerated, and the teeth loose. The face becomes pale and cachectic, the submaxillary and other glands in the neck become painful, and the secretion of saliva excessive. Speech is slow and indistinct, owing to involvement of the muscles of articulation; the patients lose their power of walking and become depressed and melancholy. Females suffer from suspended menstruation and pregnant women often miscarry. Many of the workers succumb to phthisis and to kidney disease. Others become the subjects of convulsions or are seized with paralysis, or they develop symptoms not unlike those observed in general paralysis, but without the inequality of pupils and the grandiose ideas characteristic of the more classic affection. The children of workers in mercury are often ill-nourished and rickety, and statistics show that they die from pulmonary phthisis in larger proportions than the children of persons employed in other occupations.

Cases of industrial mercurial poisoning occurring in the practice of medical men must be reported to the Chief Inspector of Factories at the Home Office. So far as the workpeople are concerned, scrupulous attention must be paid to details: personal cleanliness with frequent ablutions is a necessity, the hair and beard should be kept short, overalls should be worn when at work and astringent mouth-washes used—*e.g.*, alum, to which, when the gums are sore, potassium chlorate should be added—respirators should be worn, the sponge in which should be dusted with sulphur, workrooms should be well ventilated, and there ought to be periodical medical examination of the persons employed. In factories where several different processes of manufacture are carried on, those connected with mercury should be relegated to separate rooms, in which the temperature ought never to be high, owing to the ready volatilisation of the mercury.

Manganese

Dr. von Jaksch, of Prague, has drawn attention to chronic poisoning in manganese workers. Three of his patients, all men, in the early stage of the illness exhibited an uncontrollable desire to laugh and to weep, such as is observed in hysteria, but as these passed away, symptoms indicating a deeper implication of the nervous system showed themselves. A year afterwards the men could not walk properly: they exhibited the peculiar staggering gait met with in locomotor ataxy. Embden, another medical practitioner, has described similar symptoms in four manganese workers. In still another of Von Jaksch's patients there were signs of mental derangement as well as incoordination in walking. The poisoning is attributed to the inhalation of oxides of manganese. Experiments upon animals have not given confirmatory results, but as in Von Jaksch's and Embden's patients it took four years' exposure to develop symptoms, the time spent in experiments was probably too short. In manganese works means should be provided for removal of dust and the ventilation should be ample.

Iron and Steel

Iron ore is seldom found in nature in such a state of purity as not to be required to undergo some such preparation as roasting in order to get rid of foreign material. This is carried on in large furnaces, into which iron and coke, with or without other substances, are placed. Atmospheric air is driven into the furnaces under high pressure. The temperature is raised extremely high, so as to allow of fusion of the metal taking place, after which it is run off in a molten form into pits of sand, the result being bars of pig-iron. In another portion of this book attention is directed to the accidental poisoning by carbon monoxide of the men who charge the furnaces and who superintend the tapping processes. The work of the blast-furnaceman is hard: he is exposed to rapid and great changes of temperature, and as a consequence runs the risk of becoming chilled and of suffering from bronchitis and rheumatism. He frequently gets burned, and on a windy day is often blinded by the sand of

the pit. As a class, blast-furnacemen are apt to be intemperate in the use of alcohol. Owing to the arduous and exposed nature of their employment they age quickly.

In order to produce finished iron, the pig bars are heated in a furnace, where they undergo the process of "puddling." The work of a puddler is extremely hard. It consists in the impure iron being rolled about in the furnace by means of two long iron tools, called "paddle" and "rabble," so as to get rid of the carbon. The iron thus treated forms a large round ball. In this form it is removed from the furnace. Apart from exposure to the excessive heat, the work entails upon the men considerable muscular exertion. They perspire freely and drink correspondingly. Many puddlers are prematurely old. In consequence of the severe muscular strain, heart disease, especially disease of the aorta and its valves, is common in these men. Puddling is justly regarded as one of the most injurious occupations in an ironworks. In consequence of steel having replaced iron in shipbuilding and other industries, the demand for finished iron is becoming less and less, and as a result puddling is a decaying trade.

In consequence of their hard work blast-furnacemen and puddlers are liable to fatigue and to burns and other accidents. The labourers who remove the large pieces of slag to the tip-heap are occasionally injured by the mass exploding, owing to the vibration caused by the transport or the tension of the gases enclosed within the outer coating of the slag.

In iron and steel foundries finished steel in a molten state is poured into moulds. The risks incurred by the men thus employed are mostly the results of injuries and the effects of dust. If the moulds are not sufficiently dry—and this remark applies particularly to the large moulds in the pit of Bessemer steel works—explosions may occur and be attended by fatalities. In this country there are few statistics relating to the maladies and deaths of men employed in ironworks, but in Germany statistics show that the deaths are mostly from diseases of the respiratory organs, of which pulmonary phthisis forms 35 to 41 per cent. The average age of moulders who die from tuberculous phthisis is 41·8.

Blacksmiths and forgemen may be dealt with here. The work of hammermen is hard. In the North of England it is a frequent cause of hypertrophy of the heart and disease of the aortic valves. Much of the work previously done by hammermen is now done by machinery. When heavy hand sledge-hammers were more in use than now, there was a form of paralysis of the muscles of the arms known as "hammermen's paralysis." My surgical colleague at the Royal Victoria Infirmary, Mr. H. B. Angus, tells me that a great many forgemen still seek advice there on account of a painful inflammation of the joints of the wrists and elbows. In regard to "strikers' arthritis" it is interesting to note that the affected joint does not improve rapidly under treatment, even after all work is forbidden. Notwithstanding the apparent healthiness of the occupation a considerable proportion of the men die from lung diseases, including tuberculous affections. Heart disease, too, is common in the men.

Although Longfellow in his poem has popularised the brawniness of the blacksmith's arm and on examination a marked degree of muscular hypertrophy is frequently found to exist, still in several instances I have been struck by the feeble physique of many blacksmiths. The introduction of machinery has allowed a feebler class of men physically to enter the trade. Where the work is very hard and there is excessive use of the arm, rupture of muscular fibres of the upper arm and shoulder has been known to occur, followed by inability to use the arm. In consequence of the men standing for many hours daily exposed to high temperatures and subsequent chilling of the body, lumbago is a common complaint. Owing to similar causes I find kidney disease frequent in men employed in iron-fitting workshops. Anæmia, too, is often met with, due to excessive heat; and in consequence of the carbon and iron dust blocking the pores of the skin, eczema and boils are not unknown. Ironworkers and boiler-makers, especially the latter, suffer from deafness owing to the great shocks to the ears from the loud noises of hammering. How the hammering causes the deafness of boiler-makers, which is as extreme as it is common, it is difficult to say. Probably there is considerable shock to the

liquid in the labyrinth of the ear, and there is induced a brusque displacement of the terminal endings of the auditory nerve: these are either paralysed or become the seat of some abnormal irritation, which is subsequently followed by loss of function.

Preventive measures consist in putting on adequate clothing after exposure to heat, so as to protect the body from chills. To prevent boiler-makers from becoming deaf the ears might be stopped with cotton wadding.

Steel Grinding and the Polishing of Metals by Files and Emery-wheels

For several decades Sheffield steel-grinders have had an unenviable notoriety on account of their high mortality from pulmonary consumption, and when we consider the nature of their employment this is readily understood. There are two kinds of steel-grinding, the "dry" and the "wet," and as the work is of a special character, only trained men can earn good wages. A period of apprenticeship has to be served. The grinding is done on circular stone wheels driven by steam or water-power. Many of these stones are obtained from quarries in the neighbourhood. Considerable care has to be exercised in their selection, for as they have to be run at great speed the slightest flaw in the stone may cause it to burst, and the fragments, flung in all directions, may inflict serious or fatal injuries on the men in the workshop. Previous to using the grinding-stones they are *raced*, or run, so as to find out whether any flaws are present.

So far as the two methods of grinding cutlery are concerned, the dry method is, from a health point of view, the more dangerous to the workers. The dust is dry, and is in the form of a very fine powder, which readily reaches the lungs owing to the attitude of the men when at work. Steel-grinders sit astride the grinding-stone on a saddle, and as they lean forward, keeping close to their work, they cannot but inhale some of the dust, which is a mixture of steel and stone. Forks and needles are generally ground by the dry method; knives, scissors, and razors by the wet. Some are

ground by both methods, *e.g.*, the backs of razors and scissors are ground by the dry method and the remainder of the blade by the wet. It was in 1865 that Dr. T. C. Hall, of Sheffield, drew attention to the high death-rate of steel-grinders from pulmonary phthisis. The average age at death of steel-grinders was at this period only twenty-nine years, but of late this has improved. Dr. Hall's statistics referred to dry grinding. In wet grinding the running stone passes through a thin layer of water in a trough below the stone, so that, as its surface is always kept wet, comparatively little dust is given off during the process of grinding; but while the atmosphere is clearer of dust, the floors and walls of the workshop are damp and cold. The grinding is carried on in rooms called "hulls," which are bounded by three blank walls; the windows are without glass. Where dry grinding is carried on there are fans, but these often prove ineffective. It is no uncommon thing to find men engaged in different processes in one large room, so that the dust which is generated affects not only the workman sitting at his own grinding-stone, but the other inmates of the room as well. In Sheffield it has been ascertained that in every 1,000 deaths among steel-grinders pulmonary phthisis is the cause of 345, and other respiratory diseases 295; that is, collectively, pulmonary diseases account for 64 per cent. of the entire mortality, whereas among the adult population of the country generally phthisis accounts for 144 deaths per 1,000, and other respiratory diseases 182, or collectively 32·6 per cent. Steel-grinders die comparatively young. Dr. Sinclair White, in "Dangerous Trades," p. 414, says that 458 grinders in every 1,000 die between the ages of 35 and 55, compared with 261 in every 1,000 of the entire male population of the country. Only 140 grinders out of every 1,000 reach the age of 55 and upwards, whereas for every 1,000 of the adult male population 391 reach 55 years and upwards. Sinclair White is of the opinion that phthisis is not so rife among steel-grinders as formerly. In Dr. Hall's time the average age at death from phthisis was 29 years; at present it is 43.

What has been said of Sheffield is equally true of the dusty steel trades of the German town Solingen, of which a

graphic account has been published by Dr. Arthur Shadwell in "Industrial Efficiency," vol. i. p. 211, &c. Solingen is the Sheffield of Germany. In the town of Solingen and the neighbourhood it is estimated that there are 29,000 persons employed in making cutlery. Here all sorts of steel goods are made—knives, forks, scissors, and swords. A good deal of the work is done by the people in their homes, and it is interesting to know that the home industry is rather encouraged by the local authority, which provides the men with gas and electric power. So prevalent is pulmonary consumption among the grinders in Solingen that it has attracted the attention of the Government Factory Department. In the ten years 1885–95, 72·5 per cent. of the deaths among knife-grinders in the Solingen district was due to phthisis, against 35·3 per cent. for the rest of the population over 14 years of age, and an official examination showed that out of 1,250 grinders, only 85 men were over 45 years of age. Dr. Shadwell speaks approvingly of the methods adopted in some of the Solingen factories to deal with the removal of dust. Oldendorf, in writing about the grinders at Solingen, states that 24·7 per cent. reached 50 years of age and 3·3 per cent. 70; that at Runsched 33·8 per cent. reached 50 years and 8 per cent. 70; while at Kronenberg the numbers were 32·9 and 8·7 respectively. The mean age at death of grinders employed in the dry methods was 39·4, of workers in iron, 48·3, and of the rest of the male population 54·4 years. Taking all ages, the deaths from tuberculosis per 100 cases were for grinders, 78·3, ironworkers, 59·0, other persons, 46·0. Dr. John Tatham, in "Dangerous Trades," p. 137, is equally outspoken. He says the mortality among cutlers is enormous. At all ages it is very high, but at ages beyond 35 years it exceeds the standard among occupied males generally by from 64 to 72 per cent. The comparative mortality figures for cutlers between 25 and 65 years of age is 1,516, as compared with 1,000. It is, in other words, 59 per cent. more. Their mortality figure for phthisis is 382, and for respiratory diseases 518, against 106 and 115 respectively, the figures for agriculturists.

When we recall the position assumed by the steel-grinder

bending down upon the stone when at work, it is easy to explain, in consequence of the constrained position, the deformity of the chest wall that is occasionally observed in apprentices to the trade.

As the hulls and grinding-wheels in Sheffield usually belong to property owners, who let off the rooms, often singly, to men who again sublet the stalls to cutlers who are piece-workers, and who contribute their share financially for the motor-power supplied, it has been difficult to determine the proper individual upon whom to fix the responsibility for the provision of fans for the removal of dust, better ventilation, and the maintenance of the rooms in a clean and dry state. There are about wet grinding hulls a dampness and a stagnation of the atmosphere which rather predispose the workmen to pulmonary diseases. The wearing of respirators has been recommended, but the men say they find it irksome to work in them. Grinding wheels ought to be provided with hoods connected with fans, which would not only remove dust but would also improve ventilation. As already stated, no grinding-stone should be mounted until after careful examination of the stone by a competent person, and it should be "raced" or tested first, both as to speed and endurance, at a time few workmen are present in the room. Dry and wet grinding should be carried on in separate departments.

An interesting comparison is made between Solingen and Sheffield by Mr. C. Johnston in the Annual Report of the Chief Inspector of Factories, 1906, p. 106. The atmosphere of Solingen is bright and clear. It is seldom that black smoke is seen escaping from the factory chimneys. This is largely the result of careful firing and the use of coal briquettes instead of ordinary coal, which entails the use of slack coal. The day's actual work is nine hours; on Saturday work ceases at 5.30 p.m. The factories in Solingen are said to be marvels of order and cleanliness; the floors are of concrete and the air-space for each worker is 565 cubic feet. All the grinding-stones are protected by guards. The walls of the workrooms are limewashed every year; the floors are swept clean every evening and damp-wiped once a week. The "racing" of grindstones is never undertaken during working

hours except under a stream of water or unless the stone is entirely enclosed in casing except at the working place of the raising tool. One of the features of Solingen is said to be the large number of "home workers." These workmen own their houses, behind which is a garden, and at the rear of this their small factory. There are 1,475 small factories of this type in the district. In these the greater part of the grinding and glazing of scissors and razors is done. The floors are kept clean and provision is made for the removal of the dust during grinding. Cutlery manufacture is recognised as a dangerous trade in Solingen, and in recent years considerable improvement has taken place in the means to prevent dust. With the clean and tidy appearance of these tenement factories those of Sheffield compare most unfavourably. In Solingen the grindstones and polishing-wheels are run towards the worker; in Sheffield they are run away from the worker, so that the dust has an upward tendency and flies into the room.

There is a branch of the steel and iron trade which may be causative of phthisis and to which not much attention has been paid medically. I refer to "metal dressing," which consists in chipping off the rough surfaces and removing the incrusted sand from castings, also of smoothing them down by means of chisel and hammer. The work is similar to that of the stonemason and is equally dusty. As several men may be employed in the workshop doing this particular work at the same time, the atmosphere frequently becomes extremely dusty. Inhalation of the dust may lead to pulmonary troubles, especially in men who have a history of phthisis in their family. The disease affects the base of the lung in the early stages. During the course of the malady I have seen hæmoptysis occur.

Bronzing in Lithographic Works

The gilding of show-cards, advertisements, and Christmas cards is effected by dry bronzing. Bronze powders are ot various colours—red, green, golden, silver, &c. Ordinary bronze powder is composed of copper and zinc with 0·12 per

cent. of arsenic. In the silver powder the copper is replaced by tin and antimony. Bronzing may be done either by hand or by machinery. No matter the method employed, there is a considerable quantity of fine dust raised into the atmosphere, which falls upon the hair, the face, and the hands of the workers. In the visits of the Dangerous Trades Committee to several large establishments where this work is carried on, no specific malady was found which could be attributed to this occupation. The bronze powder which falls upon the skin is apt with some persons to cause considerable itching. The girls frequently complain of headache, and many of them are anæmic, but these symptoms are as much the result of working in close and warm rooms as of the occupation. The dust when inhaled may cause catarrh of the respiratory passages and upset the digestion. Personal cleanliness and free ventilation, with restriction of the work of dry bronzing to a particular room, will obviate many of the complaints. Several employers of their own accord, in the belief that it is a prophylactic or preventive, give milk to the workpeople.

Wallpaper Staining and Colouring

The first fatal case of arsenical poisoning from wallpaper occurred in 1858, but prior to that date many of the operatives engaged in the trade had suffered in health. Fifty years ago it was not uncommon for wallpaper to contain as much as 59 per cent. of arsenite of copper. In 1877–78 the Medical Society of London reported upon the matter. Since then there has been considerable improvement in the manufacture and colouring of wallpaper. Vegetable colouring materials have replaced mineral pigments, and as a consequence there has been nothing like the amount of sickness amongst the workmen or in people from sleeping in rooms whose walls are covered by coloured papers. It is impossible to visit a factory in which wallpaper is coloured without being overpowered to some extent by the high temperature of the rooms. In some of the rooms we found the temperature to be 89° to 91° F. on a cold winter evening and when a Blackman fan was running.

After the wallpaper receives its "ground" colouring by being passed through troughs containing coloured liquid, it travels onwards through several machines to receive its pattern and different colours. It may have to undergo "flocking," "bronzing," or the laying on of "mica" powder, all of which are more or less dusty processes. The mica dust is composed mostly of silicate of magnesia.

The dangers of working are mainly those incidental to dusty occupations generally and to exposure to working in overheated rooms. Since the abolition of lead and arsenic as colouring agents wallpaper staining has ceased to be the unhealthy occupation it was a few years ago.

Personal cleanliness of the workmen and the use of baths, the wearing of respirators in dusty processes, the wearing of overalls and head-coverings, also the free use of fans, have already improved the health of persons following this occupation.

Extraction of Gold from the Ore: Cyanide and Mercurial Processes

Gold is extracted from the ore by the battery and cyanide methods. (*Vide* also p. 225.) Over crushed ore which has been placed in a vat a solution of potassium cyanide is poured, varying in strength from ·05 to 0·5 per cent., and after an exposure of from 12 to 24 hours or more, according to the character of the ore, the cyanide solution is run off. The cyanide liquor contains the gold, probably in the form of a double salt. The solution is caused to flow over pure metallic zinc shavings, when the gold is deposited as a slime on the zinc. This slime is removed, roasted, and smelted, when pure gold is obtained. During the earlier operations the hands of the workmen have to be dipped from time to time in the cyanide liquor, and if the immersion is frequent or protracted the skin of the hands and arms becomes the seat of a "scabby" rash. The men are frequently provided with long indiarubber gloves, but these are not always worn, either through indifference or because they get torn. In hot weather the air in the neighbourhood of the vats is strongly impregnated with the

cyanogen vapour, to which some men, especially white men, appear to be extremely susceptible. Many of the white men employed at the vats suffer from severe headache, nausea, and inability to take food. The dark races do not similarly suffer. The Kaffirs occasionally suffer from the skin eruption on their arms and hands, but they do not experience the severe headache, which in the white men may last for two days, attended by a distaste for food and by insomnia. Aperients relieve these symptoms, but the best results are obtained from antipyrin or phenacetin and caffeine. Owing to the responsible nature of the work and the money value of the product, only one or two white men are allowed regularly to undertake part of the work, but it is the dark-skinned men who have to dip their hands deepest down into the slime and do the cleaning up.

Gold ore may be treated in another way. After having been crushed it is driven by water upon amalgamated copper plates which have been smeared with mercury. The gold unites with the mercury. This is scraped off at intervals and retorted. During the process of retorting mercurial fumes are given off, the inhalation of which is the cause of the falling out of the teeth and hair of the workmen, the excessive salivation and the tender gums, for which the men are obliged to use mouth-washes and gargles of potassium chlorate.

Emery-wheels

In the grinding of steel by emery-wheels large quantities of dust are given off, and occasionally a wheel breaks. When this accident occurs the fragments, owing to the speed at which the wheel is running, are thrown off with very great force, and often inflict serious injury. The wheels are made from emery rock, an extremely hard stone imported from Smyrna and the island of Naxos. The stone is an anhydrous oxide of aluminium with flint, silica, and iron. Grinding-wheels are sometimes made from another stone called corundum, which is also an oxide of aluminium, and is as hard as emery. In either instance the rock is ground by heavy

rollers into fine powder. This is collected. A considerable amount of dust is generated during the crushing, but as this is carried on in encased machinery the workmen are not exposed to the dust to any extent.

Emery-wheels are made of crushed emery-stone along with such binding substances as shellac, indiarubber, oil, sulphur, and silicate of soda, all pressed firmly together in a mould under hydraulic pressure. Into many of the wheels brass wire-webbing is inserted, so that should a wheel break when running there would be less risk of fragmentation taking place. Emery-wheels have to run at great speed. They frequently make as many as 7,000 revolutions in a minute. The wheels are used for shaping the handles of knives, and as the handles of knives are held together by steel rivets and tangs, large quantities of steel and emery dust are given off, the inhalation of which by the workmen is unavoidable unless respirators are worn or suction provided for drawing the dust downwards and away from the face of the worker. The emery-wheel—called in the trade the "cutler's glazer"—was introduced into Sheffield about thirty years ago, and it is maintained that since the introduction of the "glazer" cutlers, as a class, have become even more unhealthy than they were in previous years.

Recently several steel-grinders working at emery-wheels have consulted me on account of soreness and dryness of the throat, which they attribute to the dust given off by the emery-wheels. It is a common complaint among the hands working in a particular shop that even the men who are not employed in grinding suffer equally owing to the dusty atmosphere. The throat becomes dry and sore, and there is created an intense thirst and a desire to drink. The fauces are observed to be dry, red, and irritable. In addition to the dust, the men complain of a very disagreeable odour given off by some of the emery-wheels. I have met with one or two cases of pulmonary phthisis among the younger men, but how far this is related to the work and the throat condition I am not prepared to say. By keeping the men off work for a week or ten days the throat symptoms usually disappear.

Manufacture of Galvanised Iron

This is an industry which is largely confined to Birmingham and the Black Country. Before being galvanised the sheet-iron and hollow-ware have to be "pickled." This consists in plunging the iron into a solution of hydrochloric acid, which cleanses the iron. During this process pungent fumes are given off which are extremely unpleasant and distinctly irritant. The metal is thereafter plunged into the galvanising bath, which contains molten zinc or spelter. Upon the surface of the molten metal handfuls of ammonium chloride are from time to time thrown to prevent oxidation. When the ammonium chloride is thrown on clouds of thick white smoke arise. By persons regularly following this occupation the fumes given off in both these processes seem to be on the whole well borne, but to a new hand they are extremely irritating and causative of cough. The work is dirty; there is a good deal of smoke, and the fumes hang long about the workshop. There ought to be very free ventilation. The men who follow this occupation suffer from rheumatism and bronchial affections owing to the work being carried on in buildings that of necessity are more or less draughty.

Tin-plate Workers

In the tinning of canisters, iron boxes, &c., the iron is dipped into a bath of molten tin, whereby a lustrous white coating is obtained. The process was introduced into Wales from Saxony more than two centuries ago. Tin-plating is an industry still largely confined to Wales. In Monmouth, Glamorgan, and Caermarthen the largest works are to be found. The beautiful valleys of those counties have been spoiled by the smoke from the works. In order to be tinned iron plates have to be specially prepared. They have first to be cleansed by being washed in water, and afterwards they are "pickled," *i.e.*, immersed in a sulphuric acid bath. On removal from the bath the plates are rubbed with dry bran or a mineral powder to remove any grease and to give a polish to the surface. Tin-plate mills are, practically

speaking, open to the air, and through them there sweep cold winds, so that the persons employed are exposed to chilling draughts. The lifting and carrying of the iron plates is hard and heavy work. Mr. Whymper, H.M. Inspector of Factories, gave, in the Annual Report of the Chief Inspector of Factories, 1888, a graphic description of an industry which remains to-day what it was thirty years ago. The account of the work furnished by Miss Rose Squire, H.M. Inspector of Factories, is a piece of sorrowful reading. The work is hard, dusty, and wet. In the large mills there is a commingling of the sexes which is beyond supervision. In washing the plates the women become thoroughly soaked. It is impossible for them to keep their skirts, underclothing, and boots dry. An equally wet, unwholesome, and somewhat degrading occupation is that of the girls who have to carry the iron plates to and from the pickling bath, in which the plates are dipped in sulphuric acid solution. The girls are literally soaked through to the skin by this acid solution, which destroys their clothes. The fumes given off by the sulphuric acid are unpleasantly strong, and pervade the whole of the works. For the removal of the fumes and the steam the workpeople rely upon the draughts through the mill dispersing them. The workpeople suffer from inflammatory affections of the eyes, accompanied by a discharge, dryness of the throat, nausea, and giddiness; the teeth become black in consequence of the sulphuric acid fumes, and the hair falls off. Occasionally the girls wear a handkerchief over their mouth as a protection.

Girls and young persons from fourteen to eighteen years of age are employed in the tin houses in rubbing with bran, or some other powder, the *tinned* plates, so as to remove any grease that may be present and to give them a polish. Machinery is being gradually introduced into the mills, and is supplanting hand-labour; but no matter by what means the work is done, there will always be a considerable amount of dust raised into the air, which, with exposure to the chilling winds sweeping through the mills, will render the workpeople liable to pulmonary troubles and bronchitis. The heavy

burdens which some of the young girls are forced to carry ought to be lightened, as the weights are far beyond their strength and physical development. It is not uncommon to find in the tin-plate works of South Wales girls carrying iron plates from 40 to 100 lbs. in weight.

CHAPTER IX

DISEASES DUE TO ORGANIC AND INORGANIC DUST, HEATED ATMOSPHERE, ETC.

Dust

DUST is the enemy of the workman. Much ill-health and most of the industrial diseases are caused by the inhalation of dust or by the workpeople swallowing it along with their food. Dust, if insoluble, may inflict injury mechanically; if soluble, it may cause poisoning, as in plumbism. In the various industries dust of all kinds is met with. It is inorganic and organic. The dust given off during the chiselling of stone, the grinding of steel, and the packing of pigments is inorganic, while that raised during the manufacture of cotton, silk, and jute is organic. Dusts that are harmful might be spoken of as mechanical and irritative, chemical and toxic, or caustic.

How to deal with the dust on our roadways and streets is a problem that will sooner or later have to be seriously faced, for the increasing employment of motor-cars, motor buses, and locomotives is the cause of an amount of dust being thrown into the atmosphere such as has never previously taken place in this or any other country. What is said of the open road applies with equal cogency to work on underground railways. The Rapid Transit Railroad of New York runs for twenty-one miles under the city. There is a suspicion that the dust of this subway has an injurious effect upon the men who spend the greater part of the working day therein. Dr. G. A. Soper, Consulting Sanitary Engineer of New York, has, in the *Medical Record*, April, 1906, published a report upon the air and the dust in this subway. The temperature is 5° F. higher

than that of the streets in summer, and in winter it is 16° F. higher. Whether the increased temperature is anything more than disagreeable remains to be seen. There is the risk to passengers, when standing at overheated underground stations, of their becoming chilled by the cold draughts that occasionally blow through the tunnel. Samples of air were taken from the underground railway for analysis and compared with those of air from the streets. About eighty oxygen determinations were made; the average for the subway was 20·6 per cent. by volume, and for the outside air 20·7 per cent. The oxygen difference between the two is therefore small.

More than 2,000 analyses of the air of the subway were made in order to determine the amount of carbonic acid or carbon dioxide present. At no time was the amount of CO_2 large; the greatest amount was 8·89 volumes in 10,000 volumes of air. It is interesting to know that the amount of CO_2 apparently fluctuates in subways at different hours of the day and night, and that even in the streets there is perhaps a seasonal variation in the amount of CO_2 present. Mr. Soper says: "It may be a surprise to many to know that when the trains are moving the air circulates not only in and out of the subway but from station to station with remarkable freedom, and that there is but little more carbon dioxide in the air between the stations than at the stations themselves." There is always a certain amount of air in the subway that is not immediately forced into the streets by the trains. Examinations were made of the number of bacteria present in the air of the underground railway and of the streets. There were 3,200 bacteria per cubic metre in the air of the subway and 6,500 in the streets. The microbes found in the subway probably came from the streets, for they varied in number with those of the streets and were more numerous in the underground near the stairways than at the ends of the stations. The dust, too, that was carried down the stairways by inrushing currents of air always contained more micro-organisms than the dust of the subway, and there were always more bacteria at the end of the station platforms where the trains departed from than at the arrival end. How far these bacteria were pathogenic, and what their origin, it is impos-

sible to say. They are always present in large numbers where human beings congregate, and yet the bacteria were fewer in the underground than in the air of the streets. Some of them are probably harmful. In the absence of sunlight in the subway the longevity of pathogenic micro-organisms is increased. Pneumococci, which are the cause of pneumonia, lived in the subway 21 days but only 4 days in the streets.

On examining the dust of the underground, it was found on chemical analysis to contain 61·30 per cent. of iron, nearly all of which was in the metallic state, 21·94 per cent. of organic matter of vegetable and animal origin, 15·58 per cent. of silica and other matters insoluble in acid, and 1·18 per cent. of oil. There were on an average 61·6 milligrammes of dust in 1,000 cubic feet of air; the maximum weight was 204 milligrammes. Compared with the dust in the streets, that of the subway was 11 to 800 per cent. heavier. While some of the dust in the underground is carried in from the streets, much of it is of underground origin, and comes from the gradual wear and tear of the wood, cement, and other materials that have been used in construction, also from the operation of the trains, for the largest percentage is iron dust, and is due to the grinding action of the powerful brakes on the cars. The loss of weight in the brake-shoes alone is estimated to be about one ton per mile per month, and when there is added to this the loss from the wheels and the railway track, the origin of the metallic dust is readily explained. It is the finer dust only that rises into the air of the underground, but it is the breathing of the fine dust given off in certain trades, *e.g.*, steel, scissor, and needle grinding, that is the cause of *pneumokoniosis*, or that form of lung disease which terminates in fibroid phthisis. What the effect of the inhalation of the dust is upon the health of the men employed on the underground there has scarcely been sufficient length of time to show, but the conditions which are present point to the advisability of a railway company which controls both underground and surface running giving alternate employment to the men, so as not to have them always in the subway. Although no serious disease has been found in the men, yet many of them suffer from inflammatory affections of the nose,

throat, and windpipe, and also from "dry pleurisy" unaccompanied by pain. I have dealt at length with Dr. Soper's article because it is the most complete study of the subject that I have met.

It goes without saying that some trades are dustier than others. The amount of dust in a cubic metre of air will vary from 0 mgm. in the clean air of a dwelling-house to 175 mgms. in such an industry as felt-shoe making. In a dusty trade like cement-making Arens[1] found, when no work was being done, 130 mgms. of dust in 1 cm. of air; and during work, when the crushing machines were running, 224 mgms. According to Hesse,[2] a workman following his occupation for ten hours a day would inhale the following quantities of dust in grammes:—

	Per Day.	300 Days per Year.
Horsehair works	0·05	15
Sawmills	0·09	27
Flour mills	0·125	37·5
Iron foundry	0·14	42
Tobacco works	0·36	108
Chemical works	1·12	336

One of the dangers to health attendant upon following a dusty occupation is the development of lung disease which terminates in fibroid phthisis; hence the term "stonemasons' phthisis," "steel-grinders' phthisis," and "potters' rot." Inhalation of gritty dust is the cause of the structural changes which occur in the lungs. Calmette, of Lille, has recently disputed the respiratory origin of pneumokoniosis. He is of the opinion that the fibroid disease of the lungs is the result not of workmen breathing irritating particles of dust, but of swallowing them with their food, and that the dust particles, penetrating through the lining membrane of the alimentary canal, find their way into the lymphatics and are carried by these canals to the glands in the abdomen and also to the lungs. Calmette pleads for an intestinal as against a respiratory origin of the disease. While in no way denying

[1] *Archiv. für Hygiene*, 1894.
[2] *Viertelj. f. Gericht. Med. N.F.*, vol. 36, p. 329.

that, as in the case of pathogenic micro-organisms, dust may reach the lungs *viâ* the intestinal canal, facts and clinical experience alike point to the respiratory passages as channels also by which dust reaches the lungs. It is only necessary to examine, either by the naked eye or microscopically, the expectoration brought up by a man who has been working in a dusty atmosphere for a few hours. In addition to particles of dust imbedded in the mucus, smaller particles are seen in the interior of the mucous corpuscles and epithelial cells. The respiratory passages are lined by a layer of ciliated epithelial cells, whose function it is, owing to the to and fro movement of their ciliary processes, to waft outwards particles of dust that have been inhaled. Were it not for this protective barrier, dust would reach the lungs much more frequently than it does. The effect of recurrent colds and bronchial catarrh is to cause shedding of these cells, and consequently a loss of their protective influence. With this gone, dust more readily reaches the lungs, and entering the walls of the pulmonary alveoli, it induces a low form of inflammation which ends in the transformation of the spongy substance of the lung into hard, unyielding fibrous tissue, quite unfitted for the purposes of respiration. On the dust reaching the lungs several of the finer particles are taken up by large cells which come from the walls of the alveoli, and these cells, known as phagocytes from their power of eating and thereby destroying microbes, have also the power of absorbing dust particles. Phagocytes are endowed with a certain amount of mobility. They pass through the wall of the alveoli and, reaching the lymphatics of the lung, either deposit the pigment within them or in the surrounding tissues, or they carry them to the bronchial glands at the root of the lungs. The fibrotic lung disease that is induced through inhalation of dust extended over a length of time is in the first instance a non-tuberculous disease, but as the malady is of slow development and the man keeps to his work and is thereby exposed to accidental infection, the opportunity is afforded of the tubercle bacillus becoming grafted upon the chronic inflammatory affection and of converting it into one of a tuberculous nature.

There are various forms of dust diseases of the lungs, or *pneumokonioses*, *e.g.*, *anthracosis*, due to coal-dust; *chalicosis* and *silicosis*, due to sandstone and mineral grit; *siderosis*, due to iron; and *byssinosis*, to cotton fibres.

The following table taken from Sommerfield's book on diseases of occupations shows the important part played by dust in causing pulmonary phthisis :—

	Number of Deaths due to Phthisis per 1,000 Persons.	Number of Deaths due to Phthisis per 1,000 Deaths.
Occupation without production of dust	2·39	381·0
Occupation with production of dust	5·42	480·0
Population of Berlin of same age ...	4·93	332·3
Trades giving rise to—		
A. Metallic Dusts:	5·84	470·6
(*a*) Copper trades	5·31	520·5
(*b*) Iron "	5·55	403·7
(*c*) Lead "	7·79	501·7
Trades giving rise to—		
B. Mineral Dusts:	4·42	403·4
Pottery Workers	14·0	591·0
Masons	4·26	382
Trades giving rise to—		
C. Organic Dusts:	5·64	537·04
Dust from Leather, Skins, and Feathers	4·45	565·9
Dust from Wool and Cotton...	5·35	554·1
" " Wood and Paper...	5·96	507·5
" " Tobacco	8·47	598·4

British statistics are equally interesting. In the table on p. 248, which is extracted from Dr. John Tatham's interesting article in "Dangerous Trades," p. 135, we observe that there are several industries in each of which the mortality from phthisis and diseases of the respiratory organs is more than

Occupation.	Comparative Mortality Figures (All Causes).	Mortality Figures.	
		Phthisis.	Diseases of the Respiratory Organs.
Agriculturist	602	106	115
Pottery: Earthenware Manufacture	1,706	333	668
Cutler	1,516	382	518
File Maker	1,810	402	423
Glass Maker...	1,487	295	445
Copper Worker	1,381	294	406
Iron and Steel Manufacture	1,301	195	450
Stone Quarries	1,176	269	307
Brass Worker	1,088	279	273
Chimney-sweep	1,311	260	291
Lead Worker	1,783	148	397
Cotton Manufacture... ...	1,141	202	338

double that of agriculturists, and that in some of the trades the total mortality from these diseases ranges from three to four and a half times that of the agricultural class.

The opinion is not put forward that the high mortality of dust-producing occupations compared with that of agriculturists is due alone to irritation of the lungs caused by dust, for there are doubtless other contributing causes. Still it must be acknowledged that the influence of dust in inducing respiratory diseases of a purely mechanical and irritative nature is considerable, as witness pottery manufacture, steel-grinding, and file-making.

Cotton

If we leave out of consideration the effects of the moisture artificially introduced into weaving-sheds, it cannot be said that the manufacture of cotton is *per se* an unhealthy occupation. Much of the bad health of the workers has been the result of the reckless manner in which the moisture has been applied. In the preliminary processes of the manu-

facture of cotton, such as emptying the bales of the raw material, "carding," "roving," "spinning" the yarn, and "winding" it, there is often a considerable amount of dust, but the air-space in which the work is carried on is generally good and the ventilation is effective. In the spinning-room the temperature is usually higher and the atmosphere is not so pure as in some of the other departments of the mill. The temperature may rise to 90° or even 100° F., and as no moisture is added the air is uncomfortably dry. The opinion that previously prevailed as to the necessity of excluding moisture from this department is losing ground, and ventilation is being improved. Owing to the fact that dampness is conducive to good weaving this particular process is carried on in one-storied buildings. Factory owners build their weaving sheds as far as possible in damp situations and with only stone flags placed upon the soil to form the floor of the shed. Moist exhalations from the soil are thereby encouraged. But for moisture and warmth in the mills the cotton threads would become brittle. The roof is formed by a series of bays, and as the buildings receive their light from the north side of the bays no direct sunlight is admitted into the shed. Dr. James Wheatley, in dealing with the health conditions of the cotton-weavers, states that the principal factors concerned are (1) fouling of the air breathed by the workers themselves, combustion of gas, dust, and emanations from the soil; (2) excessive humidity; (3) high temperatures; and (4) want of cleanliness. To these might be added the risks of sore throat, bronchitis, and phthisis by the habit weavers have of sucking the weft through the shuttle when the thread breaks or on replenishing the shuttle. The shuttle might become infected by tubercle bacilli. Several devices have been introduced to obviate the necessity of putting the shuttle to the mouth, but the weavers adhere to the simpler but more dangerous practice.

During four years of my early professional life spent in Preston, Lancashire, I saw much of the cotton operatives and their work. Thirty years ago the death-rate of cotton operatives from pulmonary phthisis was much higher than

it is to-day. During the last two decades there has been all through England a diminution in the mortality from phthisis. Workers in cotton mills have shared in this declension, although figures show that only a few years ago they were still suffering from phthisis to a greater extent than persons not similarly employed. The mortality statistics of the town of Blackburn furnished by Dr. Wheatley indicate that as regards phthisis there is a difference which is in favour of the male population of the town not engaged in cotton manufacture.

Ages.	Cotton-weavers.	Cotton-spinners.	Occupied Males.
25 to 35 years ...	1·72	2·48	1·31
35 to 45 " ...	2·11	3·09	2·21
45 to 55 " ...	1·88	2·94	1·76
55 to 65 " ...	3·75	0·6	1·43
65 upwards ...	1·45	3·95	0·47

It is pointed out by Dr, Alfred Greenwood, Medical Officer of Health for Blackburn, that since 1891 there has been a steady diminution in the death-rate of cotton operatives, and that with one excepted age-period affecting female weavers from 45 to 55 years of age, when the rate increased, the death-rate from phthisis has declined. Dr. Greenwood's figures, which deal with the years 1891 to 1905, indicate that the conditions under which cotton operatives are working are better now than at any previous time in the history of the industry, and as a consequence the mortality rate has diminished, the health of the operatives has been better, and there has been a larger output of manufactured goods.

Persons following dusty occupations occasionally suffer from lung diseases of a distinctly characteristic type, attended by an increase of the fibrous tissue of the organs, to which the term pneumokoniosis is applied. Under this term all lung diseases caused by dust are included. The dust may be of various kinds, *e.g.*, organic and inorganic. To the

lung disease caused by the inhalation of cotton particles, the term "byssinosis" is applied, but in cotton operatives a purely dust disease is seldom met with. In Lancashire the deaths from phthisis of cotton operatives were 25 per cent. of the total deaths in the years 1880–82; in the years 1890–92 the percentage had fallen to 19·6.

The improvement in the health of the cotton operatives and in the factory conditions during recent years is most gratifying. Prior to the year 1882 cotton yarns were over-sized, and this necessitated the introduction of a considerable amount of steam into the weaving-sheds to soften the thread. The over-sizing not only added to the weight of the cotton cloth and was wrong from a moral point of view, but it was harmful to the workpeople owing to the dust and flocculent material which were given off. The excessive use of steam caused the clothes of the workers to become damp and was a source of rheumatism and pulmonary complaints. The Health Committee of the Blackburn Corporation instituted an inquiry in 1888 which confirmed the statements made by the Medical Officer of Health, Dr. Stephenson, as to the injurious influences of the ineffectual ventilation of the mills and of the excessive steaming upon the health of the workpeople. These reports led to the passing of the Cotton Cloth Factories Act in 1889, whereby manufacturers were prohibited from exceeding certain limits of moisture and were obliged to have always two hygrometers in each weaving-shed. Schedule A of the 1889 Act states the maximum limits of humidity of the atmosphere at given temperatures. Although this Act, one of whose requirements is the provision of 600 cubic feet of fresh air per person per hour, was followed by good results from a health point of view, it did not satisfy the Weavers' Associations. The request was therefore made to have "steaming" abolished entirely. A careful and extensive inquiry was made into the whole subject by a Committee composed of Sir Henry Roscoe, Sir William Roberts, and Dr. Ransome, who reported to the Home Secretary in 1897. In the following year the recommendations of the Committee were embodied in a Statutory Order.

The Committee recommended the employment of pure water drawn from a public supply, or such other source as is deemed satisfactory, for the purpose of inducing artificial humidity, and that when the source of the water supply is doubtful measures shall be taken to purify it before introducing it as steam, also that during working hours the proportion of carbonic acid gas in the air shall be not greater than 9 volumes to every 10,000 volumes of air. No alteration, practically speaking, was made of the amount of moisture previously allowed. Where pains were not taken to regulate the introduction of steam the air of the weaving-shed would become foggy and the steam would condense on the walls and pillars of the weaving-shed. The clothes of the workers too became saturated with moisture, so that on leaving the warm weaving-shed and proceeding homewards on a cold evening, the workpeople frequently got chilled and became liable to bronchial and pulmonary complaints and to rheumatism. Compared with dry air, which is regarded as bracing, moist air is enervating and unfits the individual to bear fatigue, and as several of the cotton operatives are poorly clad and ill-fed the ill-health they suffer from is easily explained. Another risk of getting chilled lies in the fact that when the clothes of the workpeople are damp they become permeated with the "size," and as this may contain a fairly large quantity of deliquescent salts the clothes, already damp, become further attractive to moisture.

Add to the humidity of the atmosphere a high temperature and impure air, and while it is easy to understand how much reduced may be the vital resistance of the cotton operatives, it is difficult to say how much of the ill-health is due to excessive "steaming" and how much to accessories. Work in a hot, moist atmosphere becomes uncomfortable and oppressive simply because the evaporation of the skin is interfered with, and thereby one of the natural methods of cooling the body is prevented.

Experience has confirmed the wisdom of the recommendation of 9 volumes of carbonic acid per 10,000 of air. Although a higher standard of purity might have

been nsisted upon, the regulations have, on the whole, worked satisfactorily. To enable the standard of 0·9 per 1,000 to be maintained, it is necessary to introduce more than 2,000 cubic feet of air per head per hour. Generally speaking the ventilation of cotton-weaving sheds is good. It only requires that the electric light should replace other methods of artificial lighting, that effectual means exist for the removal of dust, and due regard be paid to the adequate provision of sanitary conveniences for the workers not closely contiguous to the weaving-sheds, also that the surroundings of these sheds should be as healthy as possible, so that only pure atmospheric air shall enter the factory.

Flax and Linen

An old Irish industry, the manufacture of linen, was revived by French Huguenots who settled in Belfast, Lurgan, and Lisburn more than two hundred years ago. Although farmers in the North of Ireland grow flax, they are obliged to buy the seed from Holland and Russia, for owing to the custom of pulling the flax early and of steeping it in water the local growth is all made use of and is not allowed to run to seed. In the spinning-room of a linen factory there is considerable moisture, partly owing to the spray thrown off during the process of "wet" spinning when the yarn is being twisted round the bobbins, and also to the presence of steam jets. As in the manufacture of cotton, the flax yarn, before being woven into cloth, is stiffened or sized by a mixture of caragheen moss, flour, and tallow, and in order to dry the yarn as quickly as possible the temperature of the room is generally high, 90° F. to 125° F.

The work in linen factories is hard, the workrooms are hot, and the atmosphere in some of the processes is too moist and in others too dusty. The hecklers, *i.e.*, the men who dress and sort the rough flax converted into tow by having been passed through a machine, frequently suffer from dryness of the throat and bronchitis attended by cough and shortness of breath. In this, as in all dusty occupations where there is dryness of the throat produced by dust,

the men indulge too freely in the use of alcoholic stimulants. The machines in the heckling department are attended by young lads, many of whom are half-timers, and although the occupation is dusty respirators are no longer worn with the same frequency as formerly. Accidents are not unknown, for the lads occasionally get caught in the machinery. Workers in the spinning-rooms suffer from headache and vertigo owing to the great heat. As the workers have to stand all day more or less on wet floors, they frequently suffer from varicose veins in their legs, œdema of the feet, and eczema. Dr. Glibert, Medical Factory Inspector, of Belgium, tells me that in Belgium many of the flax workers suffer from a peculiar abrasion and ulceration of the skin of the palmar surface of the hand owing to the irritant effect of some of the materials in the liquid used for spinning. The skin cracks and is exfoliated without pain or any sense of irritation, but as the true or deeper skin is laid bare painful prickling is experienced. Occasionally the ulceration tends to invade the deeper tissues, and while the character of the sores recalls the appearances met with in syphilitic ulceration they are not in any way related to this specific disease. The ulcers are purely the result of a local dermatitis peculiar to flax workers. Dr. H. S. Purdon, of Belfast, who had several years' experience of the maladies of linen workers, states that he is familiar with the eczema observed on the hands of spinners but has never come across the ulcers on the hands to which Dr. Glibert, of Brussels, has drawn attention. The method of preparing the flax is probably different in the two countries.

Many persons on beginning work in a linen mill for the first time suffer from malaise, known as "mill fever," the symptoms of which are nausea, vomiting, headache, and a rise of temperature. Usually the indisposition lasts two or three days. It is attributed to the disagreeable odour given off by the oil and to the stifling and moist atmosphere of the workrooms.

Dr. Purdon mentions a peculiar skin eruption, not unlike small-pox, which attacks the forearm, arm, and face of the

doffers, *i.e.*, the boys and girls, usually half-timers, who remove the full bobbins from the spinning frames, and which is the result of the irritant action of the flax, oil, and water upon the skin. Callosities are met with on the index fingers of the hecklers, and are the consequence of the pressure and friction caused by pulling the flax out of the "pins" of the machinery. Many of the spinners suffer from a painful affection of the nails of the great toe. This onychia, or inflammation of the nail, is the result of infection caused by the operatives working barefooted on the wet floor of the spinning-room. The Regulations of the Home Office have done much to improve the health of the operatives and the condition of labour in linen factories in recent years.

Jute

Whether the prosperity which has attended the jute trade in the past will be extended into the future it is impossible to say. The manufacture of jute made Dundee one of the most prosperous towns in the United Kingdom. In Dundee is manufactured nearly all the jute that is imported into this country. Roughly speaking this industry gives employment to 40,000 persons. Many of the jute mills were built in the heyday of prosperity and are well equipped. The vegetable fibre from which jute is made comes from India. The plant, an annual, grows in great luxuriance on the mud banks and islands of the great rivers of our eastern dependency. Mr. H. J. Wilson, H.M. Inspector of Factories, has written excellent reports upon the conditions of labour in jute mills. About 3,500,000 bales of jute are exported annually from India to Europe, and it is estimated that 2,900,000 bales are used in Calcutta and neighbourhood in the manufacture of cloth and sacking. The jute exported from India is distributed as follows: 1,900,000 bales come to the United Kingdom; 1,000,000 go to the Continent; and 500,000 bales are sent to America.

Jute is used for making sacks and coarse twine. Attempts have been made to manufacture it into carpets, but as these have very little wear in them the utility of jute in this

respect is far outstripped in sack-making. I have never been in such noisy factories as the jute mills of Dundee. The machinery is similar to that employed in linen mills, but judging from the annual returns there are more accidents in jute than in textile factories generally, a circumstance which may be partly explained by the less perfect system of protection adopted. Alterations lately introduced have materially diminished the number of casualties. Some of the processes of manufacture, such as those of preparing and spinning, are extremely dirty and dusty, and as the wages in these departments are lower than in the weaving-rooms, the operatives are of a distinctly inferior class. The dust given off by the raw material is irritating to the respiratory passages, and in order to reduce its effects many of the female hands resort to the use of snuff. The exhaust fans in the carding- and spinning-rooms succeed in removing much of the dust. The temperature of the spinning-rooms is uncomfortably high, and to cope with it the windows have to be kept open and the fans running. The application of oil to the jute fibre allays to some extent the dispersion of dust, but it often creates an offensive odour and a feeling of closeness of the atmosphere when the temperature is high.

The manufacture of jute cannot be regarded as an unhealthy occupation except in those departments where considerable quantities of dust are thrown off. Many of the operatives employed therein suffer from bronchial and pulmonary troubles. The statistics of the Dundee Infirmary show that a large number of the workpeople suffer from lobar pneumonia. There are few towns, unless it be the east end of Glasgow, in which the children of the poorer working classes suffer more from tuberculous affections of the glands and bones than in Dundee. This is largely the result of improper feeding and of the imperfect housing and overcrowding that are known to exist in Dundee.

As a consequence of the excessive noise of the weaving looms and of the spinning frames, aggravated by the diffusion of dust in the air, which aids in the formation of plugs of wax in the ear, deafness is a common complaint of jute workers. The hoarseness observed in persons

employed in the preparing- and spinning-rooms may be the result of dust, and also the consequence of overstraining of the voice in speaking owing to the din of machinery. Many of the new hands suffer from a kind of "mill" fever, of which headache, vertigo, pain in the back, and a sense of extreme tiredness, accompanied by a rise of temperature, are the prominent features. The symptoms continue for two or three days, when they gradually subside with or without treatment.

Two or three years ago some jute workers in Dundee died from tetanus. On bacteriological analysis the tetanus bacillus was found in dust obtained from the machinery. The micro-organism had come with the vegetable product from India, but the early detection of the microbe and the source from which it came led to an early extinction of the disease.

Although the manufacture of jute cannot be said to be an unhealthy occupation, since there is no disease specific to the employment, there is something, either about the occupation itself or the home life of the workers, that does not tend to improve the physique of the children born to jute workers. To see a factory "scaling," as it is called, or the employees coming out at the close of a shift, is always an interesting sight, but such an event in Dundee offers the occasion for serious reflection. Many of the young persons employed in the preparing and spinning departments are of diminutive height and of light weight. There are a dwarfiness about them and a degree of imperfect physical development which at once strike the observer. Girls of seventeen and eighteen years of age look from their size and build more like girls of thirteen. Many of them are anæmic and their frame is not well formed. It is difficult to attribute to its proper cause the stunted growth of young jute workers. Female labour in the factories with, as one of its attendant evils, the comparative neglect of the children from a feeding point of view, the entrance of the children upon factory life at an early age, and the overcrowding in the houses are causes not to be ignored.

Workers in teak-wood occasionally suffer from dermatitis. Willmott Evans[1] mentions the case of a joiner who had suffered from a severe form of dermatitis attended by an eruption of an erythemo-vesicular nature and of an extremely itchy character spread over the whole body, but especially abundant on the back of the hands, the face, and neck, and which, in spite of treatment, continued ten days. The eruption only came on after working in teak-wood. Eight years previously the patient had been identically affected after having been similarly occupied. Six of the eight men engaged in the workshop and working in teak suffered in the same manner, although less severely. The symptoms were attributed to the action of an essential oil which is found in the central part of the tree, and which gains an entrance into the body of the workman by the dust raised during the polishing of the wood. One of my own patients who had been employed in teak-wood suffered from vomiting followed by a vesicular eruption on the skin and a desquamative dermatitis, which was still in existence six months after the acute attack.

Shoddy and Rag Sorting

Shoddy has for its object the extraction of wool contained in rags. The industry is an old one. It is supposed to have been introduced into this country by the Moors of Spain, for they are known to have made paper from rags. It was in 1813 that the shoddy industry was commenced in Batley, and for several years rags from all parts of the world found their way to this Yorkshire town, the "rag metropolis." Since the middle of last century shoddy factories have been established in Belgium, Germany, and France. Rags are divided into two kinds, (1) cotton and linen rags, (2) woollen rags. The cotton and linen rags are made into paper while the woollen rags are converted into cloth. Although rags are gathered from all sources alike by clean and dirty persons, it is astonishing how little sickness there is, comparatively speaking, among the workpeople who have to deal with them

[1] *British Journal of Dermatology*, 1905, December, p. 447.

in the factory. Woollen rags seldom convey infection, but cotton and linen rags have been the means of disseminating small-pox.

Rag-sorters are generally women. The work is anything but pleasant. This is especially the case with woollen rags, for they so frequently harbour fleas and other pests. All bundles of rags before being opened ought, therefore, to be first disinfected so as to destroy parasites, and since rags from the surgical wards of hospitals and private patients often contain septic material, the importance of making disinfection obligatory is at once apparent. It is when the bundles are first opened that the danger is greatest. The dust given off is irritating to the respiratory passages and causes dryness of the throat. During the grinding of the rags by machinery considerable quantities of dust are thrown off, inhalation of which is extremely trying to new hands but which has little or no immediate effects on the older workpeople. Those persons who are new to the trade develop what is known as "shoddy fever," the symptoms of which are a rise of temperature, severe headache, signs of bronchial catarrh, and running at the nose. The workpeople shiver as if they were going to have a severe fever, and they complain of muscular pains. The symptoms are not unlike those met with in influenza. They rapidly decline on the workpeople absenting themselves from the factory for a few days, but they are apt, in many people, to recur on their return to work. Rags which contain a good deal of cotton have to be carbonised by being plunged into a bath of sulphuric or hydrochloric acid. By this means the cellulose or vegetable part of the fibre is destroyed and the wool can be thus extracted from cotton fabrics. When the rags are subsequently heated to dryness and are beaten, a considerable quantity of fine dust is evolved, some of which is inflammable and may be the cause of an explosion. Dr. John A. E. Stuart, of Batley, says that the older workers suffer from bronchitis and emphysema of the lungs, that the dust in the air combines with the wax in the ears of the workpeople forming plugs and causing temporary deafness, that it induces granular inflammation of the eyelids, and that by plugging the ducts of the sebaceous glands of the skin it

causes *acne*, a skin eruption characterised by spots often angry looking and with a black head. Dr. Parsons, of the Local Government Board, recommended that all workers in shoddy factories should be revaccinated, also the necessity for good ventilation of the mills and personal cleanliness on the part of the workers themselves.

Soot. Chimney-sweep's Cancer. Gardener's Cancer

Coal when burned undergoes some peculiar chemical change, whereby the soot that is formed has conferred upon it properties of a specially irritating character, for only thus can we explain the prevalence of scrotal cancer in chimney-sweeps. Men following this employment exhibit a liability to cancer several times greater than that of the general population. There is the opinion that the irritant in soot is arsenic, but whether it is this or sulphurous acid or ammonia compounds it is difficult to say. In Newcastle-upon-Tyne we seldom see cases of chimney-sweep's cancer, although it was the cause of death of one sweep in 1907. In the London hospitals and on the Continent it is not met with so frequently as formerly. According to statistics supplied by Dr. John Tatham, of the General Register Office, the comparative mortality figure for cancer among chimney-sweeps between the ages of 25 and 65 for the three years ending 1902 was 133 as compared with 63 among occupied males at the same ages. This is a lower death-rate from cancer in chimney-sweeps than three decades ago, and even later. In his article on dust-producing occupations in "Dangerous Trades," Dr. Tatham gives as the mortality figures from cancer 156 for chimney-sweeps compared with 44 for occupied males. While, therefore, the mortality from cancer has been diminishing in chimney-sweeps, it has been rising in the general population. Although usually met with in the region of the scrotum, the disease may appear on any part of a chimney-sweep's body. It is usually preceded by one or two small warty growths which ulcerate, and these, failing to heal, assume the character of an epithelioma. The glands in the groin subsequently become enlarged,

first from irritation and secondly from malignant infection. The disease makes slow but steady progress. Ultimately secondary deposits occur in such of the internal organs as the liver and lungs and in the peritoneal cavity.

Gardeners who are in the habit of sprinkling soot upon plants to protect them from slugs occasionally develop cancerous ulceration of the hand. Soot when repeatedly applied to the skin causes it to become thickened, harsh, and dry. Once structural alterations are induced in the skin, repeated irritation may lead to cancer.

Men who work in tar and paraffin and in anthracene, a product obtained from the distillation of gas-coal tar, are specially prone to suffer from warts and skin eruptions. Distillers of benzine and creasote suffer in a similar manner, although not so frequently.

Ulcers of the skin in persons who are working among coal-tar and pitch products ought not to be neglected. In the first instance the ulcer may be of a simple character and will heal if properly treated and kept free from irritation. Should it cease to heal, extirpation by the surgeon may be required.

Tobacco, Cigar, and Snuff Manufacture

The manufacture of tobacco in Great Britain is in the hands of private owners, but in several of the Continental countries the industry is a State monopoly. In France it gives employment to 16,660 workers, of whom 15,000 are females. Within the last few years French tobacco factories, as structural buildings, have considerably improved. In neither the French and Spanish factories nor in those of Great Britain have I witnessed anything to lead me to regard the manufacture of tobacco as an occupation dangerous to health. The women appeared to be quite healthy. In the Newcastle Infirmary I have been occasionally consulted by young female tobacco workers suffering from chloro-anæmia, headache, nausea, and distaste for food, but I do not think that these symptoms are met with in tobacco workers in greater proportions than in girls

employed in other indoor occupations. During the manipulation of the dried tobacco for making cigars and cigarettes there is a good deal of dust floating about in the workroom, a circumstance which led Proust to include the manufacture of tobacco among the trades which cause diseases of the lungs. Zenker, a German physician, stated at a meeting of German physicians a few years ago that he had found tobacco dust in the lungs of two persons who had worked in a tobacco factory at Erlangen, and although this finding has been supported by Merkel, these discoveries remain isolated, so that we cannot regard pulmonary *tobaccosis* as a common event. In France, opinions are divided as to whether female tobacco workers are not more prone to miscarry when pregnant than woman employed in other industries, and whether the children who survive birth do not die in greater numbers during the first year of life than children born under other circumstances. It is also stated that nicotine is present in the mammary secretion of nursing women. This statement is entirely devoid of foundation. I have, when visiting one of the large tobacco factories of Madrid, seen the women leave the workrooms at a certain hour to suckle their children, brought to be fed, and a healthier class of women, also stronger and better nourished babies, it would be impossible to find anywhere. The dangers to the health of tobacco and cigar makers from their employment have been exaggerated. On the other hand, it is only proper to state that Galezowski [1] found visual troubles in persons engaged in the manufacture of tobacco. De Schweinitz, an American ophthalmologist, reports the occurrence of amblyopia or loss of vision in persons who work in tobacco, but who do not use it in any form. He relates the case of a young woman whose symptoms disappeared when she left the tobacco factory. Against these statements may be placed the opinion of Dr. Shears, who visited the works of Messrs. Cope Bros., and who on careful inquiry did not learn of one single instance of defective sight among the 1,200 men and women employed in the factory. The works at Pantin-Aubervilliers, near

[1] "Des Amblyop. et Amauroses Toxiques," p. 47, 1897.

Paris, employ 800 persons, of whom 700 are women, but in none of these did I learn of any of the visual defects to which Galezowski and De Schweinitz have drawn attention.

France has recently introduced into the State factories a pension fund for all workers. In these factories there is a nine-hours day: the men can make 7 fr. a day and the women 5 fr. 25 c. Men and women can work therein until the age of sixty-five. The State puts aside 4 per cent. of the wages of the workers into the Caisse Nationale for pensions from the first day the workers receive wages. After twenty-five years' service in the factory, or if the workers have been invalided, the women receive 400 fr. a year (£16) and the men 600 fr. (£24); but if both of these work until the age of sixty-five the pension is larger.

As an illustration of the belief of the French authorities in the harmlessness of tobacco manufacture upon the health of the workers, I cannot do better than mention the following. In order to encourage female workers in the State tobacco factories to suckle their children, and thereby to reduce the high death-rate among infants, the French Government since August 5, 1905, offers certain monetary rewards. The women are allowed thirty days to recover from their confinement before returning to work, but on the presentation of a medical certificate that health and fitness have been regained, women may return to work twenty days after this event. During the three or four weeks the women are regarded as on the sick-list: they receive a gratuity of 30 to 45 fr. if they are working in the Department of the Seine and 20 to 30 fr. if working in the provinces. To the mother who will suckle her infant and who has returned to work in the factory, opportunity is afforded of giving the child the breast at the factory, and the State at the same time gives her, in addition to her wages, at the end of every four months, an allowance of 10 fr. per month. At the tobacco works in Pantin-Aubervilliers only one-half of the women suckled their infants, and then only for a few weeks. I saw one healthy mother who had reared her infant on the breast for ten months, and she had received the allowance of 10 fr. per

month. When there are twins the State gives, if both children are nourished at the breast, 10 fr. per month for each infant. Certain formalities have to be observed, such as the presentation monthly of the infants to the doctor of the factory, who, after satisfying himself as to the health and progress of the child, certifies accordingly. This action on the part of the French Government towards the female workers in tobacco factories is the strongest proof that the manufacture of tobacco and cigars is not an unhealthy occupation. Dr. Courtois-Suffit, who is the medical officer in charge of these factories, informs me that the work does not affect menstruation, pregnancy, nor lactation. When a woman is pregnant she receives for three months before her confinement, if in indifferent health, 1 fr. 40 c. per day while off work, and after her confinement, if she is prevented working on account of delicate health, she may for a period still receive the same allowance. Notwithstanding these benevolent offers on the part of the French Government, it is becoming the fashion of female workers who have borne children not to suckle the infants, but to send them out to be nursed.

In the manufacture of snuff, the tobacco is allowed to ferment. It requires three months for fermentation to take place. Whole stacks of tobacco are thus allowed to stand fermenting. These have to be broken down, shovelled away, and the hard tobacco ground into powder. The men engaged to do this complain that the work gives them a splitting headache and causes them to vomit. They look pale and unhealthy, the work is hot, and there is always a good deal of heavy vapour rising from the tobacco-bed in which the men are employed. When the tobacco is dry, there is a considerable quantity of dust, which the men say catches them in the throat and causes them in the morning to have brownish-black expectoration.

In the department where the tobacco leaves are primarily steeped in water, the women employed occasionally suffer from painful blisters on the hands.

CHAPTER X

MINING

Coal-mining

THE dangers to life from gas and explosions incurred by the miner in the getting of coal are dealt with elsewhere in this book. Here we are concerned for the most part with coal-mining as a dusty occupation. Fifty years ago coal-miners' phthisis, or anthracosis, was a well-known disease; to-day, thanks to the well-ventilated condition of our coal-mines, the malady has remarkably diminished in Great Britain. If proof were required of the good effects of legislation in reducing occupational diseases, we have only to turn to coal-mining and compare its past with present statistics. There are certain occupations in which those who follow them are all more or less picked and healthy men to commence with, but this cannot be said of miners. Of all occupations in this country, none is more hereditary than that of coal mining. A lad goes into the mine because his father is working there and his grandfather did so before him. Miners are therefore not a selected class of men. Although a large part of the working-day is spent underground, the occupation of the miner is not an unhealthy one. Because miners' phthisis is largely a thing of the past, and was dependent upon faulty conditions, there is the opinion that the occupation of the coal-miner rather protects him from, than predisposes him to, pulmonary consumption. When pulmonary tuberculosis is caught by a miner, it is much more likely that the infection has been caught in the home or public-house than in the pit, where the ventilation is remarkably free and the air supplied particularly pure and abundant. In old colliery villages the houses of the miners are small, and the ceilings of the sleeping-rooms are low, and

there is frequently overcrowding; but in the newer mining villages many of these defects have been remedied, gardens are attached to the houses, and in these the men can work when not following their occupation. Better housing, the provision of purer drinking-water, better food, good wages, greater railway facilities, and the establishment of reading- and recreation-rooms have done much to improve the health of the mining classes, and to raise their tone socially and morally. As most of the collieries are in the country, the air is good and the surroundings attractive enough. The daily walk of the miner to and from his work, although in many instances short, is in others sufficiently long to allow him to enjoy the walk, tired though he may be. The comparative freedom of the coal-miner from tuberculous phthisis is not confined to this country alone. According to a census of the United States, pulmonary consumption caused 10·6 per cent. of all deaths among miners and quarrymen, as against 16·2 per cent. for all occupied males, *i.e.*, the disease is nearly one-third less frequent among miners than among occupied males. In Great Britain, as Dr. John Tatham has shown, the same thing has taken place.

There are 882,345 coal-miners in Great Britain: of these 709,339 work underground. Dr. John Tatham gives the following table to show the death-rates from all causes of miners in England and Wales at several ages compared with the corresponding rates of occupied males.

	15.	20.	25.	35.	45.	55.	65 and upwards.
Occupied Males.	100.	100.	100.	100.	100.	100.	100.
Mining industry	148	112	87	78	95	121	147
Coal-miners	150	111	86	77	94	119	143
Durham and Northumberland	154	111	75	66	79	97	152
Lancashire	163	107	88	94	110	140	150
West Riding	115	92	76	77	89	126	138
Derby and Notts	93	68	69	59	73	96	118
Staffordshire	95	109	82	70	95	135	180
Monmouth and Wales ...	227	141	118	97	117	140	129
Ironstone-miner	134	90	82	66	83	91	144
Tin-miner	116	139	111	115	161	180	178
Lead-miner	118	127	130	109	116	182	240

At the ages from fifteen to twenty and twenty to twenty-five, as well as above fifty-five, miners die in the aggregate more rapidly than occupied males. In the intervening ages their death-rate is lower. A large proportion of their high mortality is the result of "accident." This factor, as well as the death-rate from phthisis, is brought out in the subjoined table, extracted from one supplied by Dr. Tatham in "Dangerous Trades," p. 157.

	Accident.	Phthisis.	Respiratory Diseases.
Mining industry	135	109	267
Coal-miners	141	97	269
Durham and Northumberland	96	94	156
Lancashire	155	102	389
West Riding	114	123	288
Derby and Notts	89	69	159
Staffordshire	135	83	319
Monmouth and Wales ...	243	107	345
Ironstone-miners...	86	90	204
Tin-miners	48	508	377
Lead-miners	43	380	325

In some of the mining centres it will be observed that colliers not only suffer less from phthisis than occupied males, but that they also suffer unequally in different mining centres. Why this should be so, it is difficult to say. This remark applies not only to phthisis, but to the death-rate generally. While the death-rate from phthisis in miners is in many places low, that due to non-tuberculous affections of the lungs is, comparatively speaking, high. The mortality of coal-miners from phthisis is at certain ages a little more than half of that to which other occupied males are subject, whereas their mortality from respiratory diseases exceeds the same standard by 21 per cent. Whilst as a class miners enjoy considerable immunity from pulmonary consumption, yet the disease prevails, and is unequally distributed amongst them, as witness the high mortality from phthisis in the West Riding of Yorkshire—123—and in Monmouthshire—107—

compared with 83 and 69 in Staffordshire and Derbyshire respectively. Dr. Tatham states that in the West Riding the mortality of the coal-miner has increased since 1881 by one-fifth, but in other counties it has decreased by one-third of its former amount. Non-tuberculous lung diseases, on the other hand, have increased.

Drs. J. M. Wainwright and H. J. Nichols,[1] in dealing with the subject of anthracosis and tuberculosis, supply some interesting figures drawn from Scranton, a mining centre in the United States, with a general population of 100,000. Taking the percentage of deaths from all lung diseases among miners as 100, they give the following as the relation :—

	All Lung Diseases.	Pulmonary Tuberculosis.	Asthma.	Pneumonia.
Anthracite mine workers	100	14	29	42
All other occupied males	114	41	7	54

Tuberculosis at Scranton is about two-thirds less frequent among miners than among occupied males, and if accident is excluded the miners live longer than occupied males. De Crocq speaks of the rarity of phthisis among Belgian coal-miners. Arnold reports that in Germany tuberculous diseases are rare among coal-miners, and that there is a prevailing opinion that anthracosis is antagonistic to tuberculosis. Seltman not only found tuberculosis rare in coal-miners, but believed coal dust to exercise a favourable influence on tuberculous processes already established. Goldman attributed the freedom of the coal-miner from pulmonary tuberculosis to an antiseptic action of the coal dust. But is coal dust antiseptic? It is a fact that when coal-miners have received injuries to their limbs in the pits the wounds, when examined by the surgeon, are frequently found to be black and the tissues powdered with coal dust. So black

[1] *The American Journal of the Medical Sciences*, September, 1905, p. 408.

and gangrenous looking are the wounds, that at first sight it would appear as if amputation of the affected limb would be necessary, and yet experience shows that, disseminated with coal dust as these wounds are, they heal remarkably well. This would suggest that there was some protective influence exercised by the coal dust. It is interesting to remember that while coal is a vegetable product and largely the result of microbial agency, on bacteriological examination the fresh coal taken from the working face in the mine is found to be sterile and free from micro-organisms. The coal dust seen in a miner's wounds is therefore in all probability sterile, and as the particles are non-irritant in character they do no harm. But the question is, Do they do any good? Wainwright and Nichols, having rendered guinea-pigs anthracotic by exposing them to coal dust, found after injecting a suspension of a pure culture of tubercle bacilli into their windpipe that although the glands and abdominal viscera showed signs of tuberculosis, the lungs, which had become black with coal dust, remained free. On the other hand, guinea-pigs not rendered first anthracotic all became the subjects of tuberculosis of the lungs after injection of the culture. A certain protective influence from pulmonary tuberculosis had been extended to the anthracotic guinea-pigs by the coal dust. Experimental results such as these just recorded, also surgical experience of miners' accidents, have suggested that coal dust possesses a distinctly germicidal action, but when this has been tested on various forms of micro-organisms, including tubercle bacilli, no such germicidal action has been found. The subject is one of considerable interest, and it presents many problems that still await solution. Since no germicidal action of coal dust has been proved, the theory has been advanced by Nichols that the protective influence is due to the calcium salts which form such a large proportion of the ash of coal dust. I do not think that either of the above theories explains the comparative rarity of tuberculosis of the lungs in coal-miners. Fifty to sixty years ago tuberculous disease of the lungs carried off large numbers of coal-miners. The coal dust was just as sterile then as now, and yet there has been a marked

be secured by the men giving up their work for several months. The symptoms are entirely subjective, and there is no necessary relation between the severity of the oscillation and the degree of incapacity for work. Miners' nystagmus has been scheduled for compensation, but the fact just alluded to is sure to raise difficulties in settling disputed cases of compensation, since one coal-miner may suffer little, although the subject of marked oscillation of the eyes, while another with less prominent signs may experience so great discomfort as truly to unfit him for work.

The diseases to which coal-miners are especially liable are few so far as the occupation is concerned. It is otherwise with the risks to life from accident. In another portion of this book a chapter is devoted to the subject of ankylostomiasis, or miners' worm disease. Before discussing the question of accidents in mines, allusion ought to be made to the prevalence of a very troublesome affection of the eyes among Westphalian coal-miners. In 1904 there were 1,030 cases of ophthalmia treated in Westphalia, and in 1905 the malady was still prevalent. This eye affection, called *trachoma*, is an inflammation of the eyelids, and is extremely infectious, owing to the purulent nature of the discharge. When miners have become ill they have conveyed the disease to their wives and children. The eyelids, when affected, are not only red, but are swollen, and contain a few hard granules like grains of sago. It is not a painful affection, but there is a good deal of intolerance to light. Trachoma, being an infectious inflammation of the eyelids, is the result of micro-organisms, cocci or bacilli, which are present in the discharge from affected surfaces. Some races are more liable to it than others. The Jews, and the Irish, persons living in certain districts of Germany and Prussia, *e.g.*, Posen, Lower Hesse, and the Lower Rhine districts, also in certain parts of France, are liable to it. The chance of the disease being introduced into the British coal-mines can only arise through alien immigrants bringing it. Cleanliness, frequent ablution carefulness in regard to the use of towels, and medical treatment are recommended.

The subjoined table gives the—

Comparative Statistics of Fatal Accidents in the Coal-mines of Different Countries: Prussia, Great Britain, Belgium, and France.[1]

I. Per Thousand Workers.

Year.	Prussia.	Great Britain.	Belgium.	France.
1891	2·89	1·55	1·41	1·66
1892	2·21	1·48	2·84	0·95
1893	2·62	1·55	1·12	0·93
1894	2·21	1·61	1·62	0·85
1895	2·54	1·49	1·33	1·20
1896	2·58	1·48	1·14	1·30
1897	2·35	1·35	1·05	1·07
1898	2·86	1·28	1·42	1·07
1899	2·31	1·25	0·99	1·35
1900	2·25	1·29	1·05	1.42
1891–1900	2·47	1·44	1·39	1·18
1901	2·34	1·37	1·17	1·21
1902	1·99	1·25	1·07	1·09
1903	1·92	1·28	1·14	1·02
1904	1·80	1·25	0·93	1·07

II. Per Million Tons of Coal.

Year.	Prussia.	Great Britain.	Belgium.	France.
1891–1900	9·17	5·1	8·02	5·7
1901	9·43	4·6	7·08	6·1
1902	8·15	4·5	6·28	6·0
1903	7·58	4·7	6·69	4·1
1904	7·15	4·6	5·65	5·4

Gold-mining on the Rand and Elsewhere

In British mines individual cases of "gassing" occur among the men, due to the use of the higher explosives, but

[1] From Circular No. 3085 of Le Comité Central des Houillères de France, 28 Mars, 1906.

they are few and far between compared with those in South African mines. During 1904–1905 there occurred in the Rand mines 30 accidents from this cause. There were 40 deaths, 9 of white men and 31 of natives; 24 persons were seriously injured. Most of the accidents were traceable to the men returning to work in a particular part of the mine too soon after the blasting; some of them were due to carelessness in the handling of cartridges, while in other instances the fumes given off from the explosives travelled to other parts of the mine, even to different levels, and produced serious symptoms in the men who were working there. Drs. Donald Macaulay and L. G. Irvine state that, of the 40 deaths, 17 were caused by *nitrous* fumes, and in one-half of these the diagnosis was confirmed by post-mortem examination. It is characteristic of poisoning by nitrous fumes that no symptoms may arise and no pain or discomfort be felt for a time, and yet within 12 to 18 hours after exposure to the fumes from the explosives people may die from acute hæmorrhagic œdema of the lungs. In mines where dynamite, gelignite, and nitro-explosive compounds are used, and where the cartridge burns rather than explodes, the gas evolved may be both nitrogen oxide (NO) and carbon monoxide (CO), so that some of the symptoms may be due to the person having inhaled both of these gases. In a perfect explosion there should be, theoretically speaking, nothing but carbon dioxide, but even when the explosion is complete other gases may be liberated. Nitrogen oxide combines readily with oxygen. It is this affinity for oxygen that renders the study of its physiological action difficult. When Sir Humphry Davy tried to breathe the gas he experienced a burning sensation in his throat and a sense of constriction of his glottis. Nysten, after injecting nitrogen oxide into the veins of a dog, found that the animal died with a rapidity proportional to the quantity of gas injected, and that death was preceded by obstinate cough, difficult breathing, small pulse, and signs of chilliness. Nitrogen oxide, by absorbing the oxygen of the blood, causes death by asphyxia.

Peroxide of nitrogen (NO_2) is formed when NO unites with O. In its free state the gas is reddish brown, is an energetic

oxidising agent, and is disagreeable to breathe. The gas recalls the odour of chlorine, but while the effects of chlorine are instantaneous and painful, and disappear without leaving any trace upon the organism when the inhalation has not been too protracted, it is otherwise with the fumes of nitrogen peroxide. During inspiration of nitrogen peroxide there is a sensation of painful burning in the throat, which ceases when the fits of coughing have rejected the poison from the lungs. A few hours afterwards, when it would seem as if all symptoms had ceased and all fear of possible complications had passed away, the individual who has breathed the gas begins to complain of severe compression of the chest and of respiration being painful; there is profuse foamy yellow expectoration, the face becomes pale, the temperature elevated, the pulse frequent and small, and the patient succumbs without loss of his intellectual functions. After death the lungs are found to be gorged with dark liquid blood and are the seat of patchy hæmorrhages, the bronchial tubes contain bloody foam, and the heart is filled with dark liquid blood. In some cases the stomach is distended by gas of an extremely acid nature, the intestines are red and the mucous membrane healthy.

The inhalation of nitrogen fumes, especially nitrogen peroxide (NO_2), is extremely dangerous. Not only are the lungs congested and the seat of hæmorrhages, but the blood itself becomes brown, and gives with the spectroscope the band of acid hæmatin, situated a little to the right of C, almost in the first third of the portion which separates C from D—which means the breaking up of the colouring matter of the blood into hæmatin and a proteid.

I have dwelt at some length upon the effects of nitrogen oxide fumes, for "gassing" of the miners on the Rand has played an important part in the death-rate, owing to the extravagant use of nitro-explosives and the comparative absence of supervision of the men. So silently, too, have been the effects produced, that men have died without ever having been aware that they had been "gassed," owing to the fumes having travelled some distance in the mine. In the blind ends of drives, in winzes and rises, where there is no aerial

circulation after blasting, the air often contains small quantities of carbon monoxide (CO) as well as of nitrogen oxide (NO), and carbon dioxide (CO_2). When the men have been discovered their candle has usually been found burning by their side, but not in every instance. This circumstance shows the desirability of freer ventilation of those parts of the mine where the air tends to become stagnant. In shovelling the broken rock in the mine Kaffir boys have become unconscious, others have died—circumstances which show that the broken rock tends, after blasting, to imprison poisonous gases, the subsequent liberation of which becomes a source of danger when the work is carried on in close and ill-ventilated places.

Mining engineers are of the opinion that the air of South African mines may be polluted by the air pumped in by compressor engines carrying in carbon monoxide and hydrocarbon vapours from the oils used for lubricating the engine. Dr. J. S. Haldane carried out a series of experiments bearing upon this point, so far as the Cornwall tin-mines are concerned, without finding any appreciable quantities of this gas in the compressor air. That the compressor air is not always pure is shown by the fact that in one of the mines in County Durham, a few years ago, an explosion occurred which was traceable to the compressor air, and in South African mines compressor air has also been found capable of exploding. In February, 1906, Drs. Macaulay and Irvine reported that a native had been fatally "gassed" in one of the Rand mines through the inhalation of gases due to an explosion in the compressor cylinder. This accident shows the necessity of using as lubricants only oils of a high flash point. The non-removal by ventilation of the gases left by explosives fired on a previous day leaves a vitiated atmosphere for the men to work in. The amount of CO present under these circumstances has been found to be 0·13 to 0·22 per 1,000 and CO_2 to be 1·39 to 1·79, and in the worst instances to be 0·38 CO per 1,000 and 4 CO_2. The inhalation of minute quantities of these gases, continued over a long time when at work, must induce deteriorated health and predispose to illness.

The effects of nitrous fumes upon the miners are more or less immediate, but the men in the South African gold-mines run other risks to health which in the end are equally destructive to life. I refer to gold-miners' phthisis. In the *Lancet* of June 14, 1902, I believe I was the first to draw the attention of the Government and mining officials to the high death-rate from pulmonary phthisis in miners working on the Rand. My experience was gained in miners who had returned to Northumberland during and shortly after the close of the Boer War. A few years previously young miners in the bloom of health had left their Northern homes for the South African goldfields, and after working there four to six years returned to Northumberland and elsewhere broken in health, but with their purses lined with gold, often to the extent of £800 or £900. As nearly all of these men died, their wealth had been secured at a tremendous cost—loss of health and life. In my paper in the *Lancet* I raised the question as to whether something could not be done by improving the working conditions in the mines to put an end to the excessive mortality that was taking place in the Rand miners. Mr. Chamberlain appointed a Commission to inquire into and report upon the subject of phthisis in the miners of the Transvaal. To a mining community like that upon the Rand the prevention of miners' phthisis is one of the most important problems socially and economically. The death-rate from pulmonary diseases in metalliferous miners is unusually high. This is due to the fact that the men who work therein are exposed to dust, gases, and infection. To these must be added the influences of working in deep mines and close to blasts, also the chilling of the body consequent upon the rapid changes of temperature which the men experience in their transit by the "lift" from deep levels with high temperatures to the surface, where the temperature is low. Exposure to such rapid changes of temperature when the men are overheated and perspiring, and are fatigued at the end of their day's work, is responsible for much of the bronchial catarrh and bronchitis the men suffer from, and which could be prevented by the establishment

of "change houses" at the mine head where the men could divest themselves of their wet working clothes, have a warm bath, and put on warm dry clothing before going home.

By "Rand miners' phthisis" is meant a deeply pigmented and somewhat solid condition of the lungs found in men who during life exhibited signs and symptoms of a progressive pulmonary disease more or less of a chronic character. As far back as 1703 miners' phthisis had been described by an Italian, Rammazini, and in our country Pearson in 1813 described the disease and attributed it to dust. Doubtless it was coal-miners' phthisis these writers referred to. It was left to Peacock to establish the relationship between dust and lung diseases by demonstrating, both chemically and microscopically, the identity of the dust found in the lungs after death with that of the atmosphere in which the patient had worked. In the various pneumokonioses, or lung diseases caused by the inhalation of dust, the lesions in the lungs are, practically speaking, identical, quite irrespective of the nature of the dust. The lung substance instead of remaining soft and spongy, becomes converted into a hard, unyielding substance, composed for the greater part of fibrous tissue. Thus structurally altered, the lungs are unable to discharge their function as organs of aeration.

On examining my first patient the subject of gold-miners' phthisis I was struck by the healthy bronzed appearance of his skin. The man looked as if he had been exposed to the sun and the weather. He had the appearance of a man in good health, and yet he could not walk a few paces without panting. In his chest there were all the physical signs of fibrotic lung, with slight displacement of the heart, caused by retraction of the newly-formed tissue in the lung. Within a few months this patient died, the pulmonary symptoms having become progressively worse, and yet there was nothing like the emaciation of the body that is observed in ordinary tuberculous phthisis. What is peculiar to "gold" or "Rand miners'" phthisis is its subtle origin and development. The unobtrusive manner in which the disease invades the lungs without producing symptoms is a noteworthy fact, but once the disease has

gained a good hold upon the lungs, circumstances at any moment may arise to cause marked ingravescence of the physical signs and symptoms. One of the earliest signs exhibited by a Rand miner who is becoming "lunged" is shortness of breath. The patient who is the subject of miners' phthisis does not feel that he is really ill until he is almost beyond work, whereas in tuberculous phthisis the individual is often very ill long before there is extensive disease of the lungs, owing to the fact that the tubercle bacilli secrete toxins which poison the blood and the nerve centres. In gold-miners' phthisis the loss of flesh and strength is so gradual that the miner continues to follow his calling, for the cough is slight and there is little or no expectoration. By degrees a sense of weakness impresses itself upon the patient, but it is the shortness of breath that obliges him to give up work. When the disease is fully established, it is observed, in addition to the dulness in the chest on percussion, that the breath sounds are coarse and tubular, but in the absence of accompanying bronchial catarrh moist râles are not usually heard. There is often pain in the chest, owing to the presence of a limited pleurisy over the patch of fibrotic lung, which explains the adhesions that are found after death binding the lungs to the chest wall internally. There is, as a rule, neither the rise of temperature nor the evening sweating which are present in tuberculous phthisis, and "blood spitting" is an extremely rare event. So markedly absent is expectoration in uncomplicated cases that it is difficult to obtain sputum for bacteriological examination. In the early part of the illness, and sometimes throughout the whole of it, as in some of my own patients, the expectoration is free from tubercle bacilli. In other instances, towards the end of life tubercle bacilli are found in the sputum. This circumstance, the physical signs and symptoms, as well as the course of the disease, point to Rand miners' phthisis as being in the first instance a purely local affection of the lungs, the result of irritation by dust, and without tubercle. When the disease becomes tuberculous it is in consequence of superadded infection. In the report pre-

sented by the Transvaal Medical Society to the Government Commission on miners' phthisis occur these words: "Out of a series of 30 sputa from cases of disease of the lungs of miners examined by a member of your Committee only two or three were found to contain tubercle bacilli," a circumstance which "leads us to conclude that while in some cases a true tuberculous phthisis may co-exist, or may be superadded, the conjunction is only seen in a minority of cases."

In mining it is not the coarse particles but the fine, impalpable dust which is the source of danger, and which, in consequence of the arduous nature of the work in an overheated atmosphere, is drawn by the miner into the recesses of his lungs owing to the deeper breaths he is obliged to take. On examining, as in one of my own experiments, the lungs of a dog that had breathed for several hours daily an atmosphere rendered dusty by finely-crushed Transvaal rock, the dust on microscopical examination could be seen lying in the finest ramifications of the lungs, and also in the interior of large cells, some of which were lying loose in the alveoli. These large cells are phagocytes, or microbe-eaters, and have the power of moving about in the lungs and of transporting both organic and inorganic particles. They tend to keep the lungs free from dust, and therefore play the part of scavengers, for while they may be expelled with the expectoration they may also penetrate through the epithelial lining of the alveoli into the lymphatic vessels, and pass with the lymph stream to the roots of the lungs, where they deposit the dust particles in the bronchial glands. The long black lines of pigment which are observed in the lungs after death mark the course by which dust particles have been carried. The walls of the alveoli become thickened as the result of the irritant action of the dust particles causing overgrowth of fibrous tissue—hence the term fibrosis of the lungs. The rapidity with which the phagocytes remove the dust particles from the lungs is remarkable. After the exposure of an animal for a few hours to a sooty atmosphere the bronchial glands when examined a few days subsequently will be found to contain large quantities of carbon. It is for this as

well as for other reasons that we cannot accept as the sole explanation the theory of the intestinal origin of pneumokoniosis mentioned in another chapter. Dust diseases of the lungs are probably more frequently the result of inhalation of dust directly into the lungs, than of the ingestion of it through the alimentary canal, and the proof of this is borne out by a study of Rand miners' phthisis. The disease is principally met with in rock-drillers or in those who work in the dustiest atmosphere. Rock-drills driven by compressed air raise a larger quantity of dust than do hand drills. In all dry mines, such as those of the Witwatersrand, the blasting, drilling, shovelling of the rock and the breaking of it by hand produce great quantities of dust, which under the microscope are seen to be sharp particles of a siliceous nature. It is when the miners are "raising," *i.e.*, drilling a hole upwards, that the greatest amount of dust is created, since owing to the upward inclination it is less easy to inject water into the hole when drilling than when boring in a horizontal or downward direction. The amount of dust raised varies from 0·083 to 0·185 grain per cubic foot of air, so that a miner breathing his average 21 cubic feet of air per hour would run the risk of inhaling about 2·38 grains of fine dust per hour; hence the large quantity of silica found on chemical analysis in the lungs of gold-miners after death, amounting frequently to 24·4 per cent. of the total weight of the organs. Of 1,377 rock-drill miners employed in the Witwatersrand mines prior to the South African campaign, 225, or 16·34 per cent., died during the two and a half years immediately preceding the war. The average age at death of rock-drill miners, according to the report of a Special Committee of the Transvaal Medical Society, was under 35 years, and the average number of years the men had worked the machines was seven to nine years. Rock-drillers on the Rand are carried off by lung disease long before the prime of life, when they are still young men comparatively speaking. Some of them die very quickly and even unexpectedly. My experience of Rand miners' phthisis, based upon exam-

ination of the men who had returned to Newcastle and the neighbourhood from South Africa, leads me to express the opinion that a shorter period of rock-drilling than seven to nine years kills off most of the men, also that "raising" and "driving" are more dangerous than working in "stopes," and that dry mines are more dangerous than wet mines. There is a case recorded in the Report of the Miners' Phthisis Commission of two brothers, who, after working rock-drills for four years, "raising" all the time, died from lung disease at the ages of 28 and 30 respectively. Further evidence in support of the short life of rock-drillers is supplied by Dr. L. G. Irvine, of Witwatersrand, who says, taking a limited period of years, that "on the Geldenhuis Deep twenty-one men, having worked rock-drills for an average period of five years, died from chest disease at the average age of 35·5 years; on the Geldenhuis Estate thirty-three men who had worked 6·9 years at rock-drills died at an average age of 34·4; on the Jumpers Deep thirty-nine men who had worked rock-drills for 6·8 years died at the average age of 37; on the Crown Reef we got the names of thirty-two men who had worked rock-drills for 8·8 years, and who died at the average age of 32 years. . . . Later on we got from the Crown Deep a list of forty-nine men who had worked rock-drills on an average for six years, and died at the average age of 36·6." The shortest time on record of death from miners' phthisis after working rock-drills is three years. What has impressed me particularly in regard to Rand miners' phthisis is that while the men knew what a dangerous occupation gold-mining was, they still went on with the work, unconscious that their own lungs were becoming impregnated with dust.

The miners on the Rand are paid for piece-work; they are impatient, and as they prefer to run risks, some persons may say that the men are not altogether free from blame. They rush back too soon after blasting to recommence work in the particular part of the mine, the air of which contains a slight excess of CO_2 when the explosion has been complete, and always a large quantity of dust. They neither allow

the gas to clear away nor the dust to settle. The men work in the mine 9 to 9½ hours per day. Some patients have told me that they had frequently worked 11 hours per day. The men do not leave the mine for food, except at a few mines north of the Rand, where the men who are working machines, and are not in charge of the "boys," come up for dinner at midday. Many of these men rush to the boarding-house and sit down to meals without washing their hands. They wash afterwards. As they can make £50 to £60 a month, they make haste to be rich, and to accomplish this they despise all the laws of hygiene. The white men know quite well the danger they are running, but many of them are indifferent to their fate.

While comparatively easy to obtain statistics relating to Rand miners' phthisis among white men, it has been difficult until lately to know how the disease has affected the Kaffirs, since many of them on becoming ill return to their kraals, where they die often unknown to and unheeded by the employers. There is one circumstance which ought to diminish the liability of the "boys" to the malady, and that is that the Kaffirs do not follow the occupation with the same constancy or as long as the white men. Once they have made a little money they return to their homes, but if perchance they have become the subjects of dust lung disease and have had grafted on to it tuberculosis, they absent themselves from work and disseminate tuberculous disease among their families in the kraal.

It was not until October, 1902, that statistics were kept of native labourers. The mortality of natives working in the mines is high. In a return presented by Dr. C. L. Sansom to the House of Commons on native mortality at the Rand mines for six months from October 1, 1902, to March 31, 1903, of 70,235 employed 1,476 died, the death-rate being 42·03 per 1,000. The percentage of deaths from pulmonary disease alone equalled 42·8, or almost one-half of the total number. It is stated that "pulmonary diseases amongst natives working in the mines are partly due to carelessness and ignorance of the native, who does not realise that whilst he is living and working in a colder climate and a

higher altitude than he is accustomed to, he should take some ordinary common-sense precaution against getting sudden chills when heated by exertion, partly due also to working in a dust-laden atmosphere and general living conditions in compounds." Two diseases at this date were responsible for the high death-rate, which in the latter half of 1903 rose to 80·36 per 1,000, viz., pneumonia and phthisis, but enteric fever, dysentery, diarrhœa, and scurvy also contributed. Since 1904, although the mortality has been greatly reduced, it is still too high. The death-rate is not equal in its incidence upon the natives. Those drawn from certain territories suffer more from sickness and have a higher death-rate than others. Of the natives who died, 45·2 per cent. died within one month after allotment to the mines. After this period the mortality shows a steady decline; the "boys" apparently become acclimatised to the work. The character of the work, too, is of importance. Eighty-five per cent. of the deaths occurred among underground boys" and 15 per cent. among those working on the surface. It was hoped the provision of "change" and bath houses, drinks of hot coffee on coming out of the mine, and the distribution of warm clothing would do much to diminish this high death-rate. Since, too, the deep-level mines showed a higher mortality than the outcrop mines, much was expected from better ventilation and keeping the temperature of the mines down to 75° and 80° F. The normal temperature of the human body is 98·5° F. The effect of muscular work in a warm medium is to raise the temperature of the body to 101° F., and while this may cause little inconvenience or discomfort, a further rise of 1° may not only cause considerable discomfort, but unfit a man for work. The human body has to get rid of the excess of heat principally by radiation and evaporation. In a hot mine, say 80° to 90° F., saturated with moisture, the loss of heat by radiation is very slow. There are several factors contributing to the heat of a mine, *e.g.*, the number of men working, use of lights and explosives, the heat given off by the metals in the rock by oxidation, also the temperature of the air driven in by compression, which is 5·5° F. for every 1,000 feet of descent.

Mr. Hugh F. Marriott[1] gives a series of investigations on the depths and temperatures of South African mines. The mines varied in depth from 497 to 3,916 feet, and the temperatures from 68·5° F. to 83·2° F. In order to measure the temperature and secure as equable results as possible, a five-foot hand-drill hole was made in the rock near the floor and filled with water, the mouth of which, after being plugged with clay, was left untouched for 24 hours or more. Although the proportionate increase of temperature with depth varies considerably in different localities, still the increase is always in direct proportion to the depth. In the Witwatersrand Goldfields the mean rate of increase was found to be a rise of 1° F. for each 208 feet increase in depth, or 0·48° F. increase for 100 feet depth. Starting, therefore, from the mean temperature of 1,000 feet depth as equivalent to 68·75° F., Marriott gives the following:—

Depth, Feet.	Degrees Fahr.
1,000	68·75
2,000	73·55
3,000	78·35
4,000	83·15
5,000	87·95
6,000	92·75
7,000	97·55
8,000	102·35

The natural ventilation of the mines decreases the rock temperatures in the vicinity of the workings from 5° F. to 10° F. Work in high-temperature mines is exhausting. A miner can cool himself by removing the greater part of his clothing when the temperature of his own body rises, but when the temperature of his environment rises to 100° F. and the air is saturated with moisture, it is impossible for him to do hard work for any length of time. I have not had any personal experience of the Rand mines, but I have

[1] "A Record of an Investigation of Earth Temperatures on the Witwatersrand Goldfields and their Relation to Deep Level Mining in the Locality." Institute of Mining and Metallurgy, London, March 15, 1906.

incidentally seen the effects of high temperatures upon the men who work in the Hungarian mines at Sopron-Brennberg, whither I went to study the question of ankylostomiasis. Here the temperatures are high. The men work practically without any clothing. The day's work is eight hours, but the men can only work four hours. Owing to the high temperature the men are obliged to rest and to come out of the working into the main ways for air. As a consequence of working in high temperatures the Sopron miners seemed to me to be prematurely old, and as a result of their profuse perspiration the men were all thin and of spare body, and a large number of them suffered from functional and organic disease of the heart. The effects of working in high-temperature mines are throbbing of the head, increased frequency of the pulse, discomfort in breathing, and physical exhaustion. On the Rand, as already stated, the miners at the end of their shift, when fatigued and perspiring, are rapidly lifted from great depths to the surface, where the temperature is considerably lower, a process that cannot but be attended by risks to health from sudden chilling of the body.

In the Transvaal Native Affairs Department Annual Report for the year ending June 30, 1906, it is stated that the recommendation of "change houses" at the shaft heads and the provision of hot coffee for the native labourers has been largely adopted, also that shelters have been erected to prevent exposure to the low temperatures, which have been regarded as the cause of chills and pneumonia. Much of the high death-rate was no doubt the result of the insufficient care exercised by recruiters in the selection and allotment of natives, many of whom were physically unfit for the mines. From July, 1904, to December, 1905—

The total death-rate among natives in mines was	45·5 per 1,000
The death-rate among natives from tropical areas was	127·2 per 1,000
The death-rate among natives from British Central Africa was	154·5 per 1,000

On December 31, 1905, there were employed in mines and in all the labour districts of the Colony—

Natives (exclusive of those recruited from tropical areas) ...	84,167
Natives recruited from tropical areas	10,570
Chinese	47,217

Since then much has been done to reduce the death-rate among natives by improving the recruiting organisation and by making better arrangements for the transit of the natives to the goldfields, also by improving the conditions of life at the mines. The reduction in the rate of mortality amongst natives employed on mines and works has been steadily maintained. During 1905 the total death-rate

From disease was	40·3 per 1,000
Amongst natives recruited from tropical areas was	99·5 per 1,000

(The term "tropical areas" comprises for the purpose of mortality statistics the following areas of labour supply: British Central Africa, Rhodesia, Quilimane, Mozambique, and Damaraland.) There is the greatest disparity in the relative rates of mortality amongst natives from these areas and those recruited from non-tropical areas, as shown in the following analysis of mortality:—

	Recruiting Area.	Death-Rate per 1,000 p.a. 1905–6.
Non-Tropical	Orange River Colony	13·9
	Natal and Zululand	14·9
	Swaziland	16·8
	Cape Colony	19·8
	East Coast	35·8
	British Bechuanaland	35·8
	Transvaal	36·0
	Basutoland	45·1
Tropical	Mozambique	65·8
	Quilimane	71·6
	Rhodesia	79·8
	Damaraland	113·8
	British Central Africa	166·3

When these statistics are compared with those of previous years there is observed a marked reduction in the rate of mortality among natives from tropical areas, but there is a marked increase among those from Basutoland. It is noteworthy, too, that the death-rate varies in the different mines; in the Premier Diamond Mine, in which a large number of Basutos are employed, the death-rate was 103·1 per 1,000, whereas the mortality rate of those employed elsewhere was only 27·5 per 1,000. The death returns were classified under coal, gold, and diamond mines.

During 1905–6 the mortality on coal-mines was unusually high, viz., 61·24 per 1,000, as against 44·6 during the previous year. On deep level goldmines the death-rate was 59·24 per 1,000; the death-rate on diamond mines was 56·63, and on outcrop mines and surface works 39·42 and 27·69 respectively per 1,000. In analysing the mortality rate it is noticed that respiratory diseases, of which pneumonia and phthisis have been respectively responsible for 31·6 and 14·4 per cent., have accounted for 51·2 per cent. of the total deaths—the mortality rate from pneumonia showing a slight decrease and the death-rate from phthisis an increase by 3·2 per cent. The death-rate from accidents was 5·64 per 1,000 per annum, or 12·8 per cent. of the total mortality. Through the kindness and courtesy of the Earl of Elgin I am able to supply recent statistics bearing upon this subject from a comparative point of view:—

Comparative Statement of Mortality amongst Natives Employed on Mines and Works in Labour Districts, including Natives Employed by Contractors, January, 1906 and 1907.

Month.	No. of Natives Employed.		No. of Deaths from Disease.		Death-rate per 1,000 p.a. from Disease.		No. of Deaths from Accident.		Death-rate per 1,000 p.a. from Accident.		Total No. of Deaths.		Total Death-rate per 1,000 p.a.	
	1906.	1907.	1906.	1907.	1906.	1907.	1906.	1907.	1906.	1907.	1906.	1907.	1906.	1907.
January	101,230	111,389	357	271	42·32	29·19	41	46	4·86	4·96	398	317	47·18	34·15

ANALYSIS OF MORTALITY AMONGST CHINESE MINE EMPLOYÉS IN TRANSVAAL, AUGUST, 1905, TO FEBRUARY, 1906.

Month ...	August, 1905.		September, 1905.		October, 1905.		November, 1905.		December, 1905.		January, 1906.		February, 1906.	
Population...	44,559		44,487		45,900		45,804		47,217		47,117		49,955	
Cause of Death.	No.	Rate per 1,000 p.a.	No.	Rate per 1,000 p.a.	No.	Rate per 1,000 p.a.	No.	Rate per 1,000 p.a.	No.	Rate per 1,000 p.a.	No.	Rate per 1,000 p.a.	No.	Rate per 1,000 p.a.
Phthisis ...	5	1·34	5	1·35	8	2·09	7	1·83	2	0·51	6	1·53	8	1·92
Pneumonia	2	0·54	3	0·81	3	0·79	3	0·78	4	1·02	6	1·53	2	0·48
Tuberculosis	—	—	1	0·27	—	—	—	—	1	0·25	—	—	5	1·20
Accidents ...	19	5·11	24	6·47	29	7·58	20	5·24	15	3·81	35	8·92	25	6·00
All Causes ...	62	16·69	67	18·07	72	18·82	76	19·91	73	18·55	97	24·70	79	18·97

At the time of writing further statistical tables have not been published, but through the courtesy of the Colonial Office I am able to supply figures for comparison of the two last months of the year 1906 with the two first months of 1907:—

CHINESE MORTALITY RATE, NOVEMBER AND DECEMBER, 1906, JANUARY AND FEBRUARY, 1907.

	1906.				1907.			
	November.		December.		January.		February.	
Number Employed ...	53,004		52,889		53,828		53,736	
	No. of Deaths.	Rate per 1,000 p.a.	No. of Deaths.	Rate per 1,000 p.a.	No. of Deaths.	Rate per 1,000 p.a.	No. of Deaths.	Rate per 1,000 p.a.
Phthisis	4	0·91	4	0·90	6	1·34	3	0·67
Pneumonia	2	0·45	1	0·23	4	0·89	4	0·89
Tuberculosis... ...	4	0·91	5	1·14	3	0·67	1	0·22
Accident	30	6·79	21	4·76	29	6·46	19	4·24
Total Deaths from all Causes	82	18·56	58	13·15	82	18·28	60	13·39

I have not included in the Chinese mortality tables the number of deaths from homicide, suicide, and the opium habit. In comparing the mortality returns of native labourers and Chinese one is struck by the fewer deaths from phthisis and accident among the Chinese. At the time of writing no case of miners' phthisis has been recorded among the Chinese, but this is only to be expected, for the work in mines has to be carried on a few years before the disease develops. There is not the least doubt that within the next five or six years many Chinese, after their return home, will die of pulmonary disease, the result of the inhalation of the rock-dust of the Transvaal mines.

When the history of the development of the South African goldfields comes to be written, posterity is sure to pass severe strictures, not altogether unmerited from a medical point of view, upon the labour conditions that prevailed, and were allowed to continue so long unheeded. The race for wealth has alike blinded employers and employed to the lives that were at stake. There has been a disregard for human life not creditable to those in charge. Employers can take care of themselves, and the employed white men ought to have taken greater care of themselves, for most of them knew the risks to health they were running; but as regards the native labourers, who were ignorant of the dangers, it cannot be said there was the thoughtful and sympathetic care extended to them there might have been. The large number of deaths from accidents in the Transvaal gold-mines has been appalling. Since such a condition of things would not have been allowed to go on at home, it is more than probable that many of the accidents could have been prevented by spending more money on plant and by bringing to bear upon the mining authorities the expression of a healthy local public opinion through an unbiassed press and through greater publicity of Coroners' courts. The high wages paid to miners on the Rand is of itself proof of the dangerous nature of the employment, and yet, high as the wages have been, they never seemed to attract for any length of time the natives to the mines.

The one disease to which in these pages attention has been

specially directed is miners' phthisis. Attempts have been made to minimise the relation of the lung disease to the dusty nature of the occupation by assigning to the dust-storms that sweep over Johannesburg some part in the production of the malady. March to November are dry months in the Transvaal. In July there are frequently great dust-storms, which are attended by variations of temperature on the surface, and yet the people of Johannesburg do not suffer from lung disease due to dust.

Although no importance can be attached to this theory of "dust-storms" at Johannesburg, it is another question as to whether there may not be something specific in the dust of the Transvaal rock to explain the prevalence of Rand miners phthisis. On this point the experience of Dr. R. H. Bremridge, who is on the medical staff of the Kolar goldfield in India, is extremely valuable. In the Kolar goldmines there are 40,000 coolies employed; the rock is hard. Dr. Brem ridge went to India expecting to meet with cases of miners' phthisis, but he failed to find evidence of the disease except in men who had come from the Transvaal. Although no precautions are taken in the Kolar mines to throw water on the surface to diminish the dust after the use of explosives, and the men work hard, yet Dr. Bremridge finds that the miners, native and white men, keep good health. He attributes the freedom from miners' phthisis partly to the fact that in India the men work eight-hour shifts, take more leisure, and are not so eager to make a fortune as the miners in the Transvaal. There is plenty of dust in the Kolar mines; it is a hard quartz rock that is blasted, and without such precautions as the spraying of water. It would seem, therefore, as if there might be something in the character of the dust itself to explain, on the one hand, the prevalence of miners' phthisis in the Transvaal and, on the other, its marked absence in India, where no special precautions are taken to allay dust. Hard and angular as are the particles of all forms of quartz rock-dust, it would appear as if in the development of the malady there is something over and above mere mechanical irritation of the lung tissue to explain why chronic inflammatory changes once induced run in some instances a more rapid

course than in others and pave the way more readily for tuberculous infection. Although miners' phthisis on the Kolar goldfield is remarkable rather for its absence than its presence, it is not so with other forms of lung disease. Dr. Bremridge finds that a large percentage of the miners die from pneumonia, due not so much to dust as to the fact that the men, after having worked hard for eight hours, are obliged to climb ladders to the height of 2,000 feet in a state of fatigue and when perspiring, and thus become chilled. The proof that this has had much to do with the prevalence of pneumonia has been demonstrated by the fact that since a skip, whereby coolies can ride to the surface, has been introduced into one of the mines from which the largest number of cases of pneumonia came, the number of cases of acute lung disease has considerably diminished.

Further support to the theory that certain forms of rock-dust are more liable than others to cause, if not miners' phthisis, certainly symptoms of ill-health, is given by Mr. R. J. Watkin,[1] who had been for several years foreman of a sampling mill in Queensland, Australia. The work in the mine was dry and dusty. He found that he almost invariably lost the services for several days of the four men who were working on the bottom floor. The ores that proved to be most dangerous were the sulphide ores; these contained, roughly speaking, 35 to 40 per cent. of silica, 20 per cent. of pyrites, 15 per cent. of zinc-blende, 3 to 4 per cent. of copper and lead. The miners attributed the illness to the presence of lead, but the quantity of this metal was small and it was in an unoxidised form, so that he could not accept this theory. Yet whenever this particular kind of ore was sampled the men became ill, and remained thus often for many days. It is more than probable that in these cases gases played an important part in the development of symptoms. Shortly after the South African War miners on the Rand were encouraged to wear "respirators," but they could not work in them. So great is the dust in the mines that, as regards the Kaffirs, their upper lip and parts immediately adjacent to the nostrils

[1] "Discussion on Prevention of Miners' Phthisis." Mining Institute, London, May 19, 1904.

often appear greyish-white, as if powdered. This rime-like appearance stands out in contrast with their dark skin.

In the mines the temperatures are high, and as the Kaffirs work practically naked, they simply throw a blanket round themselves on going from the mines to the compounds. The natives are careless in regard to falls of temperature, and are, therefore, much to blame for the chills that follow exposure to cold. The compounds are good; the natives are better fed and better lodged in them than in their straw-thatched kraals, with small doorway closed at night, and in which a fire is lit without any provision made for the smoke to escape. The native labourer is a poor specimen of mankind. His physique is bad, and he does not stand illness well. Within recent years employers have introduced many improvements. If mine-owners would give further consideration to the hygienic conditions of labour in the mines, bestow a little more personal attention upon both the white and black men employed, see that water-spraying is used with every rock-drill, spend more money on machinery, and keep it in proper condition, and would take such steps as to maintain the safe working of their cages, many lives would be saved that are otherwise imperilled, the risk of miners' phthisis would be reduced, and employers would earn—although not always expressed—the gratitude of countless workers.

Australian Mines: Bendigo

A carefully prepared report upon the health of the miners employed in the quartz mines of Bendigo, by Dr. Walter Summons, has been issued by the Trustees of the Edward Wilson Estate, Melbourne, 1906. In determining the extent to which phthisis and respiratory diseases are present amongst the Bendigo miners the death registers have been perused for the last thirty years, as prior to 1875 machine rock-drills were hardly in use. Since 1875 the number of deaths from pulmonary disease has much increased. At present there are 3,650 quartz miners employed at Bendigo, but in the year 1899 there were 3,990. The following table supplies statistical information as to the deaths of miners at Bendigo:—

ANNUAL DEATHS AMONGST BENDIGO MINERS, DETERMINED IN FIVE-YEAR PERIODS, AND ESTIMATED AS PER TEN THOUSAND LIVING AT ALL AGES.

Year.	Miners' Phthisis (Tuberculous).	Chronic Bronchitis.	Acute Pneumonia.	Total Lung Diseases.	Fatal Mining Accidents.	All other Causes.	Total Deaths.
1875–79	48·5	8·0	20·5	77·0	28·5	74·3	179·8
1880–84	56·9	13·1	17·0	87·0	32·8	70·6	190·4
1885–89	80·0	39·3	20·6	139·9	31·3	111·3	282·5
1890–94	84·6	34·4	16·9	135·9	28·4	120·2	284·5
1895–99	102·4	35·6	27·4	165·4	21·9	130·4	317·7
1900–04	100·8	23·0	21·3	145·2	14·7	96·5	256·3
1905–06(½)	129·6	34·6	27·4	191·6	9·2	69·2	270·0

Since 1880 there has been a marked increase in the number of deaths from respiratory diseases, especially from miners' phthisis. The total deaths from lung diseases have risen from 77·0 to 191·6 per 10,000, and this is largely accounted for by the increase in those from tuberculous diseases, which were 48·5 in the first period and 129·6 in 1905—an increase out of all proportion to the annual mortality rate from consumption amongst other occupied males.

Fatal mining accidents, on the other hand, have been becoming fewer and fewer, owing to the greater precautions taken to safeguard the life of the miner. The number of deaths of miners from tuberculosis is six times greater than that of adult males in Victoria generally. While the disease has been diminishing among the general population, it has been increasing among the miners, which is pretty strong proof of the unhealthy conditions under which the work in the Bendigo mines has been carried on. A large number of the men have died before reaching the prime of life. The average age at death is under fifty—slightly higher than that observed on the Rand.

The lung disease of the quartz miners at Bendigo develops insidiously, without there being at first any symptoms to attract attention, unless it be slight cough. Occasionally there are recurrent attacks of mild bronchitis, which by denuding the mucous membrane of the respiratory passages of its protective ciliated epithelium more readily allows of the entrance and absorption of particles of dust. As the

general health remains for a time good the men continue to follow their employment. With recurrent attacks of bronchitis there occurs "black spit," or the expectoration becomes muco-purulent, which on bacteriological examination, although found to be teeming with staphylococci and putrefactive organisms, is yet free from tubercle bacilli. Shortness of breath sooner or later shows itself and is a distressing symptom, for it is often severe, and is out of all proportion to the amount of bronchitis that is present. There may be complaint of stitch-like pains in the chest, due to limited pleurisies. On examining the chest by percussion, dulness is frequently detected at the base of the lungs. Along with Dr. Jackson of Bendigo, Dr. Summons examined with the fluorescent screen three patients who were the subjects of advanced fibrosis of the lungs. The lungs in each instance showed abnormal shadows that were extremely irregular in distribution, dark lines being particularly noticeable in the situation of the interlobar septa.

Men can work longer in the Bendigo mines than on the Rand without becoming affected. The average number of years worked is 22. Most of the miners presented the deep sunburnt appearance of men in health, and yet the slightest exertion would be attended by great difficulty of breathing. Summons classifies miners' phthisis at Bendigo under two heads: (*a*) pure fibrosis of the lungs, non-tubercular in origin, a true silicosis; (*b*) a mixed type, in which there has occurred a tuberculous infection of a fibrotic lung. Bendigo miners suffering from dust disease of the lungs were found to have a normal resisting power to tuberculous infection, but when infection took place their opsonic index became subnormal. Forty-seven per cent. of the men suffering from miners' phthisis became tuberculous. The high death-rate from respiratory diseases of 204 per 10,000 miners calls for some improvement in the conditions of labour and attention to hygienic details in the home. Owing to the frequency with which tuberculosis becomes grafted upon a diseased lung which at first was non-tuberculous, also to the risk of a careless consumptive patient spreading infection in the home, the greatest care should be taken to disinfect the expectoration, for at Bendigo miners'

wives have died from pulmonary tuberculosis in larger numbers than other married females in Bendigo and Victoria. Once symptoms of pulmonary fibrosis have shown themselves, the men ought to give up work in the mines, and by engaging in some agricultural occupation thus try to prolong life. It remains to be seen how far such a change of occupation will be followed by permanent good results. The mines should be well ventilated, so as to keep down dust and reduce temperatures, but as dust is the enemy most to be feared, no rock-drill should be used without a jet or spray of water kept playing in and around the hole when the drill is in operation.

Ganister Mining

Ganister or calliard, a hard, close-grained siliceous stone obtained from under the coal seam, is found in Yorkshire, Durham, and Denbighshire. When crushed and ground into dust it is made into bricks, which, owing to their great resistance to heat, are used for lining Bessemer and steel converters in ironworks. The mortality rate of the men who are employed in ganister mining is high. The miners suffer from lung disease in larger proportion than the men on the surface, but the grinders even still more, and for this the inhalation of dust is responsible. Attention has been drawn to the high death-rate of ganister miners living in the valley of the Don by Dr. C. L. Birmingham,[1] and subsequently by Dr. Robertshaw in his reports as Medical Officer of Health, Stockbridge. Ganister is so hard that, as it cannot be obtained in quantity by the ordinary methods of mining, recourse has to be had to blasting it by means of dynamite. When brought to the surface of the mine it is taken to powerful grinding mills, where it is pulverised and made into bricks. The men who are liable to ganister disease are the miners, grinders, and brickmakers. In this form of pneumokoniosis the lungs become converted into hard, almost solid material, composed for the most part of dense fibrous tissue, which unfits them for performing their function of aeration. As it is stone dust or particles of silex that are inhaled, the

[1] *Journal of the Sanitary Institute*, April, 1900, p. 67.

disease is known as *silicosis*. Both in the preparatory drilling of the rock for blasting and after the use of explosives the atmosphere becomes charged with very fine dust. It is into such an atmosphere that the miner enters after firing explosives. He cannot prevent himself inhaling particles of dust. These, becoming caught in his bronchial tubes and lungs, induce a reactive inflammation which ends in fibrosis. When the disease has gained a firm hold the miner becomes anæmic and enfeebled in health. Gradually developing a cough and becoming the subject of difficulty of breathing, he is unable to undergo the physical exertion required of him in his work, and is therefore at a comparatively early age obliged to relinquish his occupation. Dr. Birmingham supplies the following data:—

During	1894	there were	22·86	deaths from ganister disease	per 1,000 workers
„	1895	„	28·59	„	„
„	1896	„	17·14	„	„
„	1897	„	28·59	„	„
„	1898	„	14·29	„	„

or an average annual death-rate of 22·29 per 1,000 workers. The mortality rates differ as between ganister miners, grinders, and brickmakers. For every 1,000 men employed in each group there die annually:

Ganister miners	42·3
„ grinders	179·8
„ brickmakers	22·2

The mortality of ganister grinders is *eight* times as great as among brickmakers and *four* times as great as among miners. Readers may well wonder how it is possible to find men willing to follow such an occupation as ganister grinding, with a death-rate of 179·8 per 1,000 employed. Owing to the arduous nature of the work it is difficult for the men to wear respirators, and although steam jets and sprinkling with water have been introduced to allay dust, the mortality from ganister disease still remains far too high.

Tin-mining

The health of the Cornish tin-miners is dealt with in a Blue Book published four years ago.[1] Tin-mining has for long been regarded as a dangerous occupation. Within the last sixteen years the mortality from lung diseases has considerably increased in miners living in Cornwall, so that the death-rate of men aged from 25 to 45 is eight to ten times that of colliers or ironstone miners of the same age. The high death-rate of recent years has been contributed to by miners who have returned home from the Transvaal and by the increasing employment of rock-drills. Out of 320 deaths of miners in the Redruth district, Haldane found that 141 were of men who had worked rock-drills, and of these 141 men 133, or 94 per cent., died of lung disease, the average age at death being 37·2 years. Of the 179 men who had not worked rock-drills 120, or 67 per cent., died of lung disease, the average age at death being 53 years. The quantity of dust raised in rock-drilling is very great if water spraying is not made use of at the same time, and as rock-drillers have a higher mortality from lung diseases than men engaged in other processes of mining, inhalation of the dust cannot but be regarded as the principal cause of the disease. Commencing as a purely dust disease, the lungs subsequently become infected by the tubercle bacillus, and this hurries on the malady to a fatal termination. As the infection usually occurs a few years after the men have been exposed to the dust-laden air, frequently after they have given up underground work, it would appear as if the tubercle bacilli had been inhaled not in the mine, but elsewhere. Other causes of the malady than dust have been suspected, such as absence of sunlight, exposure to high temperatures, and sudden variation of temperatures, climbing of ladders, and gaseous impurities underground; but while all or some of these may reduce the vital resistance of the miner and predispose him to the more acute forms of inflammation of the lungs, they are not responsible for the chronic

[1] "Report to the Secretary of State for the Home Department on the Health of Cornish Miners," 1904.

structural changes which end in fibrosis. Taking this view of the malady, tin-miners' phthisis can be to a large extent prevented by the laying of dust during rock-drilling by water spraying, by the men not returning too soon to the particular part of the mine after the use of explosives, and by care taken, in moving the ore and conveying it to the shafts, to keep it damp as far as possible.

Slate Quarrying

The quarrying of slate by the underground method is a comparatively modern industry in Wales. Sixty years ago the slate in the Festiniog district of Merionethshire was worked in open quarries, but as the depth increased and the expenses connected with the worthless "cover" or "top" became great, underground mining was resorted to. The health of the slate-miners of Merionethshire and the conditions of labour in the mines formed the subject of an inquiry by a Departmental Committee, which reported upon the matter in 1895.[1] In this report is fully described the method of working the slate. After having made an inclined passage along the dip of the bed and vertical tunnels having been driven along the strike, the men excavate downwards and upwards, making underground chambers. The rock is removed in slices, so that an underground slate quarry is a series of working chambers and pillars, the pillars, roofs, and floors being formed of slate. The only light used in the mines is a tallow candle. Blasting is done by means of gunpowder, as this severs the slate without smashing it, but for such preliminary work as driving levels, making roofs, and cutting "free side," gun-cotton and the various nitro-glycerine explosives are used. The blocks of slate are taken to the "mill," where they are cut into various lengths and thickness, according to whether the slate is to be used for roofing purposes, for making cisterns, or billiard tables.

[1] "Report of the Departmental Committee upon Merionethshire Slate Mines," 1895. Published by Messrs. Eyre & Spottiswoode, London.

Slate-mining is not free from the risk of accidents. During the nineteen years ending 1895 there were in the Merionethshire slate-mines 147 fatal accidents, in which 163 lives were lost, due mostly to falls of roof and side during the process of getting the slate. Roofs and sides of a slate-mine that are perfectly safe when left by the *miners* and *rockmen* become less and less safe as time goes on. Air and moisture penetrate into the joints of the rock and loosen it, while the natural earth tremors and the quivering caused by blasting are not without their influence in weakening the supports. Only a small number of the accidents was traceable to the use of explosives. The average annual death-rate from accidents during the nineteen years mentioned above was as follows:

Per 1,000 persons employed underground	3·23
" " above ground	0·70
" " above and below ground...	1·94

"The occupation of the Merionethshire slate-miner is more risky than that of the average miner of the United Kingdom, but less hazardous than that of the South Wales and of the Cleveland miner." In the open slate quarries of Carnarvonshire, *e.g.*, those of Penrhyn and Dinorwic, there are comparatively few accidents: 0·76 and 0·71 per 1,000 persons employed respectively. Dr. Richard Jones, of Blaenau Festiniog, who has had large experience of slate-miners and their maladies, says that the Festiniog quarrymen are less liable to phthisis than the non-quarrymen in the district, but that the death-rate from phthisis is higher among those engaged in the slate mills than among the underground workers, the *rockmen* and *miners*. This, as might be expected, is partly the result of the dust created during the dressing of the slates. Festiniog quarrymen are especially prone to pneumonia and to diseases of the alimentary canal. There is a general agreement of medical opinion that the diseases from which slate-miners particularly suffer are: (1) diseases of the respiratory organs, especially pneumonia; (2) rheumatism and its complications; and (3) indigestion.

The cold, damp climate of the district, imperfect housing of the workers, and the undrained character of the land contribute to the causation of rheumatism and diseases of the respiratory organs. Owing to the scarcity of houses several of the men live in "barracks." These are frequently badly kept, are far from being sanitary, and are always overcrowded. The food of the Welsh slate-miner is poor—too little nitrogenous food is taken and too much stewed tea is drunk. It is interesting to note that the death-rate from phthisis is higher among the females in the district than in the miners, and that they die from pulmonary consumption at an earlier age than the miners—strong proof of the imperfect house accommodation. The mean age of females dying from phthisis is 31·4 years, of quarrymen 39·08, and non-quarrymen 35·6. In 1890 Dr. Richard Jones found that 55 per cent. of the deaths from respiratory diseases were due to pneumonia, but the usual average is 36·4. The men who dress the slates in the mills are more liable to fibroid phthisis than the men who work underground: the latter, on the other hand, are more liable to pneumonia, probably the result of chill and exposure on leaving the mines. Were it not for the fact that 5,000 cubic feet of air-space per man is the average in the mills, as against the 250 cubic feet required by the Factory Law, fibroid phthisis would be probably more prevalent than it is.

Dr. Lachlan Grant, of the Ballachulish Quarries, Glencoe, informs me that fibroid phthisis and pneumonia are seldom met with among the quarrymen there, also that pulmonary tuberculosis is more frequent among the women employed at home than among the men. All the slates are hand-cut. No machinery is used, not even hand-drills. The immunity enjoyed by the Ballachulish quarriers may be partly due to the fact that as all the work is done by hand less dust is raised.

The subject of the maladies of slate-miners in France has been carefully studied by Dr. Sejournet,[1] of Revin, at the St. Joseph slate-mines near Fumay, a small town with 5,280

[1] "La Maladie des Ardoisiers: la Schistose," Reims, 1900. Imprimerie Matot-Braine.

inhabitants, in the valley of the Meuse. The five slate works of the district give employment to 600 men—one half of whom work underground, while the remainder are employed on the surface dressing the slates. Dynamite is made use of to dissever the rock. The miners inhale the dust and the fumes caused by the blasting. In some of the slate works the only mode of exit from the deep mines is by long ladders and steps; in one mine, after a hard day's work of twelve hours, the men have to lift themselves up ladders and stairs with 1,500 steps before they can emerge—a process attended by a considerable amount of fatigue as well as consumption of time. The rough cutting of slates is mostly done by hand. A cutter can make from 1,000 to 1,200 slates per day. These are passed on to other men who by means of machinery give the required shape to the slate. Machine cutters can turn out 600 to 700 slates per hour. The work is dusty, and during the whole of the working day the men are more or less inhaling dust. The French slate-miner has been represented as a man of short stature and bent, round-shouldered and almost hunchbacked in appearance, but at Fumay many of the slate-miners are men of good physique and they carry themselves straight.

Notwithstanding this, several of the slate workers are observed to walk slowly, their chest is frequently barrel-shaped and emphysematous, and although young and apparently in good health they are short-winded compared with the men in the district who are following other occupations. Like the Welsh slate-miners, the diet of the French workmen is poor. Their food is mostly potatoes and *café au lait*, or soup and bread. Dr. Hamaide, of Fumay, who knows the slate-miners well, says that they begin to suffer from bronchitis between the ages of 35 and 40 years, and that once this becomes fixed and is followed by structural alterations in the lungs and bronchi, the malady proves fatal in 5 to 10 years. The mean duration of the life of the Fumay slate-miner is 48 years. Most of the miners die from pulmonary fibrosis, the result of the inhalation of dust. Dr. Hamaide has seen men who are the subjects of slate-miners' phthisis expectorate

fragments of hard, stony material like schist, accompanied by profuse bleeding from the lungs. Dr. Arlidge found a similar thing happen in the lung-affected potters of Staffordshire. M. Ripert reproduced experimentally pneumokoniosis in the lungs of rats and guinea-pigs by slate dust. French writers divide the lung disease of the slate-miners into three stages: (1) the period of commencement, in which there are symptoms and signs of pulmonary emphysema with difficulty of breathing and dry cough; (2) an indefinite period in which the emphysematous type of the disease may be attended by accessions of asthma, and which may allow the miner to live to the age of 60, or the disease becomes associated with congestive attacks that are followed by pleurisy or pneumonia; and (3) the terminal stage, in which the lung becomes hard and fibrotic, owing to the large amount of slate dust it contains. In 65 per cent. of the cases no tubercle bacilli are found in the sputum—a circumstance which points to the dust origin of the malady.

Stonemasons' Phthisis

The occupation of the stonemason and of the quarryman has for long been regarded as one in which a higher death-rate from lung disease occurs than in most occupations. The disease, which usually assumes a chronic character, is slow in its development and progress. As it is attended by the ordinary physical signs and symptoms observed in other forms of pneumokoniosis, the malady calls for no special description other than this, that in contradistinction to miners' phthisis, which occurs in men who work underground, stonemasons' phthisis is met with in men who are working in the open air, a circumstance which becomes a strong argument in favour of the dust origin of pneumokonioses as against the bacillary. After a time the lung disease becomes tuberculous, hence the extraordinary fact of the death-rate from pulmonary tuberculosis among stonemasons and marble cutters, who are following an outdoor occupation, being six times that of bankers and brokers, who are leading an indoor life. This want of harmony between occupation and mortality

from pulmonary phthisis is observed in other outdoor occupations than stone-cutting. It would appear, therefore, as if the predisposing causes of lung disease are often of greater importance than the exciting—in other words, that the soil is of as much, if not of greater, influence than the seed. The irritation of the lung caused by dust would seem in some instances, especially in the early stages of the disease, to create a favourable soil for the implantation of the tubercle bacillus, while in the slowly developed forms of pneumokoniosis the hard and unyielding fibrous tissue does not offer the same attractions to the micro-organism, and as a consequence it is in those parts of the lung where the structure is least fibrous that the tubercle bacilli exert their greatest power for harm.

Millstone Building

This trade is extremely limited ; it is, practically speaking, confined to the banks of the Thames and the Mersey. The stone used for making millstones is extremely hard ; it is imported from Fierté-sous-Jouarre, in France, and is known as *buhr* stone. It is a variety of quartz, and is so hard that when being dressed by a workman, the points of as many as ten steel tools will be knocked off in a quarter of an hour. A considerable quantity of steel and stone dust is given off, which the men cannot but inhale. Notwithstanding the fact that the work is carried on in the open air, these men suffer in their lungs. When, as one of the members of the Dangerous Trades Committee of the Home Office, I visited several of the yards on the banks of the Thames, I was particularly struck by the absence of old men in the trade. Buhr stone builders make good wages—fifty to sixty shillings a week—all by piece-work. Few men survive ten to fifteen years' work in the trade. They are carried off—very rapidly sometimes—by disease of the lungs. One of the earliest symptoms is blood-spitting. If the men continue to follow their employment after hæmoptysis has set in, the pulmonary disease tends to run a rapid course. Buhr-stone workers are frequently intemperate. Indulgence in alcohol reduces the vital resistance of the men and precipitates the fatal termination.

In order to study millstone builders' phthisis I went to Fierté-sous-Jouarre, in France, where the buhr-stone is quarried. In France the millstone building is carried on exactly in the same manner as in England. Similar conditions prevail among the men, there is the same tendency for lung disease to develop, and, if anything, the intemperate habits of the British millstone builders are surpassed by those of the Frenchmen. There were no old men working in the yards. Most of the men in the Fierté yards die before reaching the age of forty-five; the men, too, look old for their age. The Government inspector who accompanied me stated that the men worked on Wednesday, Thursday, Friday, and Saturday, and drank on Sunday, Monday, and Tuesday at least. This may have been an exaggerated *exposé* of the failings of the men, who pleaded to me, as an excuse for their excessive indulgence in alcohol that they suffered from an intolerable dryness in the throat created by inhalation of the dust. As a similar complaint is made by all persons engaged in dusty occupations, it is not without some basis of foundation. In discussing with the doctor at Fierté-sous-Jouarre the subject of diseases incidental to millstone builders, he alluded to the high mortality rate of the men from pulmonary phthisis at an early age, and confirmed all that has been said of the intemperate habits of the workmen. The wearing of respirators has been tried by the men, but they tend to restrict the freedom of breathing. A few of the more careful men make use of water-spraying while chiselling the stone, with the result that not only is the dust allayed but their health is better.

Manufacture of Pottery

The manufacture of pottery has for long been regarded as an unhealthy occupation. As far back as the days of Ramazzini (1670), the lung troubles of the potter had been recognised and described. With the terms "potters' rot" and "potters' asthma" the public are quite familiar. It is this liability to lung disease on the one hand and to lead poisoning on the other that has placed pottery manufacture high up on the list

of dangerous trades. The late Dr. Arlidge, of Stoke-upon-Trent, has left behind him excellent descriptions of the lung diseases of potters. Thanks to improved methods of working and the introduction of fans and strong draughts to carry away the dust from the face of the workers, the malady is becoming less frequent than formerly. Cheap pottery is made from ordinary clay, but in the manufacture of the finer ware Cornish clay and stone are used. In firing china the cups, saucers, plates, &c., are placed in "saggers," or burnt clay boxes. The contents of the saggers are kept individually apart from each other by means of ground flint, which can be used over and over again. The particles of flint are extremely sharp and angular. When drawn into the respiratory passages they set up a considerable amount of irritation and cough. This is particularly apt to occur during the "scouring" or brushing of the ware on its removal from the saggers after having been in the oven. There is also a good deal of dust thrown off during the "towing" or smoothing of the dried ware before it is fired. Under all circumstances this must be very much less than after the ware has been fired or biscuited. Although "scouring" of the biscuited ware has been rendered a less dusty, and therefore a less harmful, operation since strong down-draughts have been provided, it is still dusty, and if the aspiration goes wrong the atmosphere of the workroom at once becomes thick and unpleasant. The dust difficulty can to a large extent be got over by finishing the ware in the "green" condition. At the large pottery works of Messrs. Boulenger et Cie. at Choisy-le-Roi, near Paris, I found that the slightly moist ware was smoothed with paper before being heated. No dust at all, practically speaking, was given off by the ware when thus treated on the revolving wheels. In Messrs. Boulenger's factory the results were quite satisfactory. The workmen at first objected to the finishing of the ware when "green," but now that they have had experience of it they would not revert to the former method, with its attendant clouds of dust. In the porcelain works at Limoges I saw and learned something of the baneful effects of dust upon the men and women employed in the scouring of china. No provision was made in some of the works for

the artificial removal of the dust. Among the brushers-off in Limoges there is a high death-rate from respiratory diseases and pulmonary consumption. Of 75 deaths registered as occurring in china-makers, 36 were due to phthisis, and of 30 potters whom Dr. Raymondaud examined, 20 were suffering from phthisis. Pulmonary phthisis is regarded as the principal disease affecting the workers in the Limoges potteries. Dr. Lemaistre, with whom I had the opportunity of discussing this subject, had analysed the air of the potteries, and he found that the dust in some of the workshops is composed of earthy particles, fragments of granite, flint, particles of dried glaze from the ware, soot, and wood charcoal. The atmosphere in which the brushers-off, the finishers, and the porcelain makers generally work contained 640 million particles of dust per cubic metre of air, while several of the finishers, *i.e.*, the persons whose work consists in removing the excess of the dried glaze on the ware, are often breathing an atmosphere containing 680 million particles of dust to the cubic metre. This large number of dust particles in the air of the workrooms is one explanation of the frequency of bronchitis and pulmonary disease in pottery workers, and while these dust particles act mechanically they may, by making a breach in the epithelial lining of the smaller bronchial tubes and pulmonary alveoli, reduce local resistance to micro-organisms, and therefore pave the way for the entrance of the tubercle bacillus. The average age at death of men from fibroid phthisis in the potteries of Limoges is 43, and of the female workers 38 years. In the Staffordshire potters Dr. Arlidge found that the mean age at death of male potters aged twenty years and upwards was 46·5, and that of non-potters 54. Bronchitis is met with among the male pressers, who are exposed to the dust of the clay, but in china scourers the severer types of pulmonary disease prevail.

Much can be done by means of improved ventilation to diminish the evil. Open windows are not enough: fans and strong aspirating draughts must be provided. Scouring of china by hand over a grated trough into which the ground flint falls should be discontinued and done in semi-closed

boxes, with a strong downdraught on the offside of the workers, or by revolving brushes driven by machinery in semi-closed spaces similarly aspirated. As dust diseases of lungs develop insidiously and progress slowly, it would be to the advantage of the workers themselves if their chest was examined every few months by a doctor, for signs of commencing lung disease should be regarded as disqualifying for further employment in china scouring.

Mixed Forms of Pneumokonioses. Slag Work

Since men who are following a dusty occupation are frequently exposed to more than one particular kind of dust, so in their lungs after death there is found corroboration of the fact. In colliers who work in hard coal there is occasionally found a mixture of coal-miners' phthisis and stone-miners' phthisis, anthracosis and silicosis, in needle-grinders siderosis and silicosis, and in pottery workers silicosis and aluminosis. In the lungs of an emery grinder who died from chronic pneumonia Professor Letulle found hard masses which, on chemical analysis, were composed of silica, alum, and peroxide of iron. The slag which is left in the manufacture of steel by the Gilchrist-Thomas method contains phosphate of lime, magnesia, iron, and silica, and when ground to a fine powder is sold for the purposes of manure. In my visits to the slag-crushing works in Middlesbrough and elsewhere, I have been struck by the large amount of dust that is given off during the crushing of this refuse from the blast furnaces. If not wearing respirators the men cannot avoid inhaling the dust, and as a consequence several of them suffer from bronchitis and asthma, chronic cough, and difficulty of breathing. The men, too, are liable to pneumonia. A few years ago there occurred an epidemic of pneumonia in Middlesbrough, the nature and origin of which, for a time, remained obscure. As its ravages were particularly severe among men labouring at the blast furnaces and in the slag works, the inflammation of the lungs was at first believed to be in some way or other connected with the dusty occupations these men were following. Dr.

Ballard, of the Local Government Board, subsequently demonstrated that the pneumonia was of a specific type, and was due to the consumption of tainted meat. Although in this particular outbreak of pneumonia slag crushing was proved to be in no way responsible for the malady, in Germany slag crushers have been found to be the subjects of respiratory diseases in larger proportions than men following other occupations in ironworks.

Metallic Dust and Siderosis

Only a few cases of siderosis have been reported. For what we know of the malady we are indebted mostly to Zenker. The disease is met with in persons who work among the red oxide of iron, *e.g.*, looking-glass makers, gold beaters, glass polishers, and in men who clean the surface of rolled iron plates by means of sand. In the men employed in this last occupation, the greyish black dust which is found in the lungs and bronchial glands is the oxide of iron in the form of the magnetic oxide. Persons who are suffering from siderosis have the usual signs and symptoms of a pulmonary dust disease, with, in addition, the expectoration of reddish material due to the presence of iron. Zenker found on post-mortem examination that the pleural surface of the lung was studded with red patches, and that on section the lung substance exhibited a bright brick-red appearance. Although there were cavities in the lungs there were no traces of tuberculosis. The brick-red appearance of the lung was chemically proved to be due to the red oxide of iron.

CHAPTER XI

DISEASES DUE TO PARASITES AND MICRO-ORGANISMS

Ankylostomiasis, Miners' Worm Disease, Miners' Anæmia, Hook-worm Disease or Uncinariasis

IT was during the tunnelling of the St. Gothard in 1892 for railway purposes that European nations first came to realise what a power for harm ankylostomiasis can be. During one year when engineering operations were in progress at the St. Gothard, there were registered between October 1, 1880, and September 30 following, 186 cases of anæmia in miners. The making of the tunnel was attended by a loss of life, human and equine, which was appalling. Many of the miners were seen to become pale, to suffer from shortness of breath on exertion, their feet to swell so that the men became unable to walk, and as the illness assumed endemic proportions and had not been observed previously to any extent in Europe, the malady, since it was thought to be the consequence of men working in tunnels, came to be called "maladie des tonnelles." As pallor of the body was one of its most striking features, it was also known as "miners' anæmia." At first it was currently believed that owing to the great length of the railway tunnel, upwards of nine miles, the conditions under which the work was carried on in the interior of the Alpine mountains were extremely unhealthy, and that the men succumbed to the combined influences of excessive heat, laborious work, bad food and ventilation, also to the effect of the sudden chilling of the surface of the body when the men, fatigued and perspiring at the end of their shift, emerged from the warm tunnel into the biting cold air. The

ventilation of the St. Gothard tunnel is admitted to have been defective, so that work under the conditions that then existed could not have been other than prejudicial to the health of the miners. It was reserved to Dr. Perroncito, of Turin, to discover and point out the real cause of the malady. On making a post-mortem examination of the body of deceased miners, he found numerous small white threadlike worms in the upper part of the small intestine and adherent to its lining membrane. When the parasite was examined microscopically, it was recognised as the worm described by Dubini, of Milan, in 1838, and further as the same parasite which affects the fellaheen of Egypt, causing Egyptian chlorosis, and the field labourers of India, Ceylon, Assam, South America, Australia, &c. The malady was not therefore, as was at first thought, a new disease. As far back as 3,450 years ago there appears in a medical papyrus an accurate description of the symptoms exhibited by a person who is suffering from ankylostomiasis. In the United States of America the disease has been regarded as the result of mud or earth eating, especially among the poor white people and the negroes who live along the banks of the Roanoke River in North Carolina. It was also found years ago among the slaves of Louisiana, and attributed to the same cause. The Zoology Director of the United States Government, Dr. C. W. Stiles, describes two species of the ankylostoma, the New World parasite and the Old World parasite—the latter so called because of its having been introduced into America by immigrants from Europe. The disease is spoken of by Stiles as "uncinariasis." He regards residence on a sandy soil as one of the conditions favourable to the development of the disease. Many of the cases occur in agricultural labourers and in women and children. The women and children suffer more severely than the men. A large number of infected young persons become pot-bellied, like the Indian children who have been fed upon rice.

Since ankylostomiasis affects field labourers who are working in the glare of a warm sun equally as well as the Italian miners in the gloom of the St. Gothard, it is apparent that the disease must be due to other than

subterranean causes. Perroncito settled the point so far as mining is concerned. It was by utilising the knowledge supplied by him and others, also owing to special care taken of the miners by the medical men, that the engineers were able to make and complete the Simplon Tunnel, which is three miles longer than the St. Gothard, without any cases of ankylostomiasis appearing amongst the miners.

On the completion of the St. Gothard tunnel there were set free large numbers of Italian miners, who, in order to obtain employment elsewhere, travelled far and wide to the various mining districts of Central Europe. A few years afterwards ankylostomiasis broke out unexpectedly in the coal-bearing districts of Hungary, Germany, and Belgium, and as the disease assumed alarming proportions it called forth the united efforts of the mining authorities and the medical profession to cope with the ravages of the endemic. While this was occurring on the Continent, considerable uneasiness was created in our own country by the discovery of the disease among the tin-miners of Cornwall. The manager of the Dolcoath mine had observed that several of the miners were suffering from debility, anæmia, and œdema of the feet, and were unable to follow their occupation. He attributed the ill-health of the miners to imperfect ventilation of the mine, but on microscopical examination of the fæces, the ova of the ankylostoma were found therein. The malady had, therefore, silently gained an *entrée* into the tin-mines of Cornwall: it was the same disease as that which proved so destructive to the miners in Westphalia and Hungary.

In order to study the subject of ankylostomiasis practically, I visited the Dolcoath mine, where, through the kindness of the manager, Mr. Thomas, I had not only the opportunity of descending into the mine, but of examining infected workmen. Subsequently, in company with Mr. Belger, of Armstrong College, Newcastle, I proceeded to the infected coal-fields in the valley of the Ruhr in Westphalia, and to those of Sopron-Brennberg, in Hungary. We entered the Westphalian coal-fields by Bochum, for it is here that Dr. Tenholt lives, who is in Germany the greatest authority on the miners' worm disease. Here, too, is established the

excellently equipped *Knaffschaftsverein*, or Miners' Institute, which, while it is the official centre of the colliery proprietors and of the workmen, is also the seat of the medical administration and of mining education.

It was in 1760 that men began to win the coal in this particular district of Germany, but it was not until 1840 that the impetus was given to the coal industry which has made Westphalia the prosperous Duchy it is to-day. So great was the demand for coal a few years ago, that in one year there entered Westphalia twenty thousand miners. These men came from Posen in Prussia, from Poland, Hungary, and Italy. It is not known how ankylostomiasis was introduced into the valley of the Ruhr. Some authorities maintain that the disease was brought thither by infected Italian miners who had just quitted the St. Gothard; by others it is contended that the malady came from Hungary; while others again blamed the men who had worked in the brickfields near Cologne in the summer and in the mines in winter. Owing to the large number of miners who entered Westphalia in one year, as already mentioned, and who were of various nationalities, it is impossible to say how ankylostomiasis originated in the German coal-fields; but while the origin of the disease is unknown, there is not the least doubt that the use of water sprays in the mines, compulsorily ordered by the Government owing to the fiery character of the coal-dust and the numerous explosions that had taken place attended with loss of life, materially contributed to the spread of the disease. Water-spraying became general in 1900. In the Ruhr Valley, where most of the coal-mines are situated, the number of cases of ankylostomiasis has been as follows:—

	Cases.		Cases.
1896	107	1900	275
1897	113	1901	1,030
1898	99	1902	1,355

The increase in the number of cases of ankylostomiasis in the German mines after water spraying is more than a coincidence. It became a serious matter in Westphalia from a

health and money point of view, to say nothing of the social and economic questions which it raised. During the three years previous to my visit it cost the Miners' Union in its efforts to grapple with the disease upwards of £100,000. Nothing could exceed the excellent organisation and the hygienic methods adopted by Germany to get rid of the scourge. They are object lessons which this country, in the event of the disease becoming endemic, might follow.

In July, 1903, the Royal Department of Mines ordered a microscopical examination to be made of the excreta of not less than 20 per cent. of the underground miners living in the province of Dortmund. It was found that of 188,730 workmen employed, 17,161, or 9·1 per cent., were suffering from ankylostomiasis. When compared with previous figures, these show that the disease was declining. Investigations were also made among the families and relatives of worm-sick miners. At Arnsberg, 386 wives and 964 children of the miners known to be the subjects of ankylostomiasis were examined, but in only one case was the disease detected. As this and another case previously reported are the only cases where until that date the presence of worms has been established among the female relatives and the children, it is clear that the infection did not reside in or at the homes, but was confined to the mines. Ten to 15 per cent. of the miners had to undergo a second course of treatment.

At five of the collieries water sprinkling was, with the consent of the Royal Department of Mines, discontinued in whole or in part, so as to ascertain what would be the effect of the diminution of moisture in the pits. No particular result was noticeable at the time of the publication of the article in *Glückauf*, 1903, vol. xxxix. p. 1138, from which I have quoted, but it is believed that the mines chosen were naturally damp, and in those that were dry sufficient time had not been allowed for the results of the experiment to have been achieved.

At the Lothringen mine, which I visited with Dr. Tenholt, and where ankylostomiasis broke out in 1885, the number of infected underground workers had fallen from 72 to 8 per cent. The larvæ were still to be found in the muddy

water along the sides of the roadways in the mine and in the wooden props which supported the roofs. How long the larvæ are capable of living in the pit it is impossible to say, but in the Erin mine, a few miles away from the Lothringen, I was informed by Dr. Perner, the medical officer in charge, that he had found in one of the disused parts of the pit the larvæ alive and very active eight months after the gallery had been shut off from the other parts of the pit. At the date of my visit experiments were being conducted at the Lothringen mine by Dr. Tenholt in regard to the disinfection of the infected galleries by lime, but the difficulty of carrying this to a successful issue is apparent from the enormous extent of surface and the possibility of fresh infection by careless miners.

In Germany the ravages of the ankylostoma are not confined to the mining population: many of the brick-makers in the fields around Cologne are not free from the parasite. Surgeon-Major Talayrach ("Annal. d'Hygiène," Août, 1904, p. 182), quoting from the medical statistics of the German Army, shows the prevalence of ankylostomiasis among soldiers. This is hardly to be wondered at in a country where all the young men have to do compulsory military service. Talayrach is of the opinion that the German pits became infected by Hungarian miners who had returned from Brazil, whither the parasite had been introduced by Italian mining immigrants. In Germany there were in 1902 17,161 cases of ankylostomiasis out of 188,730 miners examined, *i.e.*, about 9 per cent. The disease is not confined to Westphalia and the Rhine provinces; it is also met with in Luxembourg and the frontiers of Alsace-Lorraine.

The German Government now requires military surgeons to notify all cases of ankylostomiasis coming under their cognisance. As a consequence of circularising the military doctors, there were reported in October, 1903, 40 cases of ankylostomiasis in the army, of which 33 were in the 16th Army Corps. Of the infected soldiers, 39 belonged to the mining districts of Westphalia and the Rhine provinces. A subsequent inquiry elicited the presence of the parasite in

28 men who had just finished their military service and who had all the appearance of good health.

An infected miner will pass in his stools myriads of ova of the ankylostoma, which in a few days, if the temperature is favourable, will develop into living, active, and voracious larvæ. Opinions are still divided as to whether these larvæ can, in the sludge of a warm mine, develop into the fully-developed worm. Giles affirms the fact, and his observations are confirmed by Sandwith, but in none of the experiments I carried out with the larvæ of the ankylostoma of the dog was such maturity ever reached. While not denying the possibility, the usual course is for the larvæ to be transferred to a host, in the upper reaches of whose intestinal canal transformation of the larvæ into the sexually mature worms takes place. There are several forms of ankylostoma, *e.g.*, that of man—in whom two kinds are met: (1) *Ankylostoma duodenale* and (2) *Ankylostoma Americanum*—also the parasite which infects the dog, fox, sheep, &c., but by most writers the organisms are not considered to be interchangeable. The larvæ of the ankylostoma of the dog cannot develop into the adult worm in any other body than that of the dog.

P. D. Siccardi (*Atti d. Reale 1st Veneto d. Sci. Vet.* &c., vol. 65, ii., 1905–6), in his review of the subject of ankylostomiasis, maintains that the larvæ of the American form of ankylostoma are incapable of infecting the dog, but that those of *Ankylostoma duodenale* can. The ova of the *Ankylostoma Americanum*, or *Uncinaria Americana*, are larger than those of the Old World parasite. They resemble the ova of *Ascaris lumbricoides* that have lost their external capsule.

At Sopron-Brennberg, Hungary, where I was the guest of Dr. Goldman, the medical officer to the colliery, there were ten years ago 70 per cent. of the miners infected, but at the date of my visit 30 per cent. The miners had suffered very severely in their general health. Several of the miners whom I saw at the works' hospital were anæmic and short of breath, their feet were swollen, and they were suffering from dyspeptic troubles, and yet the virulence of the endemic was on the wane. The conditions of work in the Sopron mine

are peculiar. The coal is of a pitch variety. In the mine fires keep breaking out several times a day. The temperature is frequently as high as 104° F., and even higher where the ventilation is imperfect and water spraying not attended to. Owing to working in this high temperature the men are all thin and spare of body. Half of the time they are in the mine they have to leave off working and go into the main galleries to get cooled. As they perspire freely, boys, carrying water barrels on their back, keep walking up and down the underground roadways in order to supply pure drinking-water to the miners.

It is not known how ankylostomiasis reached the Hungarian coal-fields. Miners from the St. Gothard tunnel are blamed, but the manager of the Sopron-Brennberg Colliery, Mr. Rudolf, informed me that as far back as 1864 he knew of the existence of the miners' worm disease in Hungary. Evidently what takes place in the infection of coal-mines is something like this. Probably one diseased and thoughtless miner is capable of infecting a mine owing to the myriads of ova passed in his stools. Grassi and Parona state that one centigramme of fæces from a miner harbouring 1,000 worms in his intestinal canal will contain 150 to 180 ova. These, as we have seen, under favourable conditions develop into larvæ, some of which sooner or later may gain an entrance into the body of healthy miners. For a period everything goes on at the pit as previously, when all at once several of the miners become ill and unfit for work. When the disease breaks out suddenly and in many of the workmen, it is usually extremely virulent. This is a feature of the malady which is lost as time goes on.

Ankylostomiasis has shown itself in the coal-bearing districts of other countries. It was prevalent in the mines of Bohemia in 1903. Belgian miners have suffered severely from the disease. As far back as 1884 the malady, according to Firket, existed in the collieries around Liége. Between 1884 and 1895 there were 92 cases of ankylostomiasis treated in the hospital at Liége, but shortly after this the number of cases became so large that a Commission was appointed to inquire into the subject. Although certain sanitary recom-

mendations were made by this body, the miners themselves refused to allow them to be put in force, and as a consequence the disease spread, so that in November, 1903, it was known that around Liége 7,000 miners were suffering from ankylostomiasis. A well-equipped bacteriological laboratory and dispensary were established at Liége and placed under the direction of Dr. Lambinet. Since then, owing to the preventive and curative measures employed, the disease has almost disappeared.

In France miners' anæmia has long been known. At the commencement of last century it was prevalent at Anzin, but here, as in Cornwall, the malady was wrongly attributed to the defective ventilation of the mines, the breathing of harmful gases, and the laborious nature of the miner's occupation. The occurrence of an endemic among the colliers at St. Etienne was proved by Perroncito, of Turin, to have been due to ankylostomiasis. To-day the disease is not unknown in the mining district of the Pas de Calais, in the North of France, also at Lens, Escarpelles, and Bruay, and so far as the valley of the Loire is concerned, the mines of Rive-de-Gier and of La Perronière have been considered the worst. On more than one occasion the malady has been made the subject of special inquiry by the French Government. It is a notable fact that in France, Germany, and elsewhere improved ventilation of the coal-mines has always been followed by a marked reduction in the number of cases of ankylostomiasis.

The malady is also met with among the sulphur miners of Sicily. The Italian climate is favourable to the free development of the ankylostoma both above-ground and underground. Giardini (*Rassegna Mineraria*, 1903, vol. xix. p. 115), says it occurs among the agricultural labourers, *e.g.*, rice cultivators, and the brick and tile makers. The disease is also met with in the mines of Venetia, the Romagna, and Sardinia. At the sulphur mines of Lercara, in Sicily, a Commission appointed to inquire into the subject found that of 20,000 workers examined 30 per cent. of the *solfatari* were suffering from ankylostomiasis. The nomadic life of the Sicilian miners is largely responsible for the spread of the

disease. As these men are extremely poor and miserably fed, the ravages of the disease are especially severe upon them. Dispensaries have been established, but the greatest difficulties are being experienced owing to the uncleanly habits and the ignorance of the miners.

The prosperity and opening up of South Africa have drawn thither miners from all the world over, to say nothing of the importation of Chinese labour. For many years past the native African population has been known to be suffering from ankylostomiasis. While the disease so far has not assumed an endemic character, still groups of cases have occurred here and there in the mines, a circumstance which calls for vigilance and medical examination of suspected new hands applying for work. Especially is this a necessity, since W. G. T. Posnett, who is pathologist to the Johannesburg Hospital, has (*Lancet*, September 15, 1906) drawn attention to the fact that in 70 per cent. of the stools of the natives from Rhodesia and Portuguese East Africa he has found the ova of ankylostoma. None of the patients exhibited symptoms of the disease. The "boys" from Portuguese East Africa and the Shangaans from the low Veldt were more frequently affected than the members of other tribes. Posnett is of the opinion that the parasite is widely distributed throughout the natives employed in the Witwatersrand mines, and that, while not a direct cause of death, its debilitating influence must be counted as a serious factor in the high death-rate prevailing among the natives.

Since Dubini's discovery of the worm the *Ankylostoma duodenale* has been found widely distributed all over the globe, wherever there exists a favourable temperature and uncleanly habits of the people. It is found in 20 to 30 per cent. of the fellaheen in Egypt, and is even more prevalent in the natives of certain parts of India, Assam, Ceylon, Japan, West Indies, &c. The ova are occasionally found in the stools of natives of warm countries who are visiting England, also in the fæces of miners and others who have returned from foreign parts. Thus are to be explained the few cases of ankylostomiasis that have been reported in Scotland. One patient was a miner, who had been previously a soldier in

India. Although the parasite is called *Ankylostoma duodenale* it is not confined in its habitat to the duodenal portion of the alimentary canal. In the dog I have found the worm in large numbers in the jejunum or upper portion of the small intestine. The worms, which are small threadlike bodies, vary in size from 8 to 10 mm. in length, by 0·4 to 0·5 in breadth. The female is the larger of the two. By means of four claw-like hooks, two on each side of the ventral line, and two conical teeth, one on each side of the dorsal line, the worm attaches itself to the mucous membrane of the intestine, and thereby secures its nutriment. The worms when passed *per anum* are white or grey in colour—white when alive, grey when dead. Others are reddish, owing to containing blood abstracted from their host. While the tail end of the female parasite is pointed, that of the male is spread out like an umbrella and contains eleven ribs. In the female the anus is subterminal; the vagina is ventral, close to the commencement of the lowest third of the body. In the male the cloaca opens into the umbrella-like bursa. When in conjugation the worms resemble the Greek letter "γ."

The numbers of ova produced and shed by the female ankylostoma are enormous. The eggs are oval in shape, and have a delicate transparent membrane, through which the yolk can be seen in the stage of segmentation. The ova vary in length from 0·056 to 0·061 mm. and are always twice as long as they are broad. Within three days after being passed by a patient the ova, under favourable circumstances, develop into actively moving filiform larvæ 0·2 mm. in length, and 0·014 in breadth. So voracious is their appetite that within a week they have grown thrice their original length. They twice undergo a process of moulting, after which they cease to be so vigorous. One reason asserted for the ova being unable to be transformed into larvæ in the intestinal canal of the host is the absence of oxygen therein. The larvæ gain admission into the human body through water or through food, owing to workmen eating with unwashed hands. Until recently this was the usually accepted theory as to the mode of entrance into the human body, but it was reserved to Looss, of Cairo, who had accidentally

Fig. 1. ***ANKYLOSTOMA DUODENALE*** **(HUMAN)**
NATURAL SIZE. THE SMALLER WORM IS THE MALE

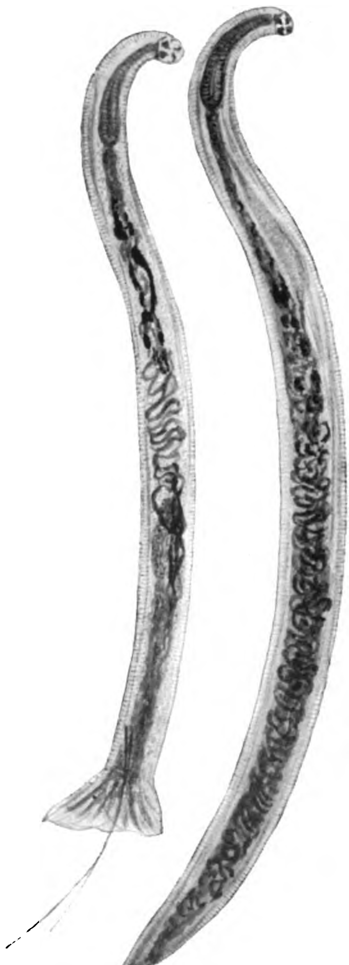

Fig. 2. ***ANKYLOSTOMA DUODENALE*** **(HUMAN)**
× 12 DIAMETERS

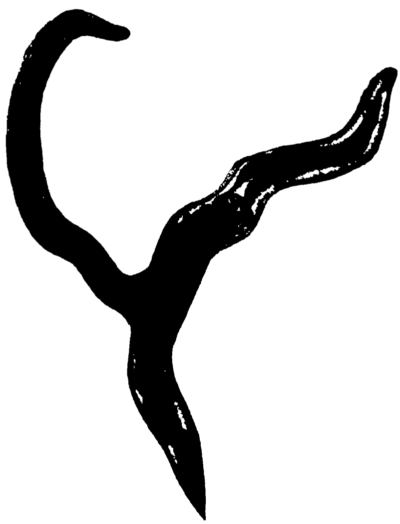

Fig. 3. *ANKYLOSTOMUM DUODENALE* (HUMAN)
CONJUGATION OF MALE AND FEMALE WORMS
× 7 DIAMETERS.

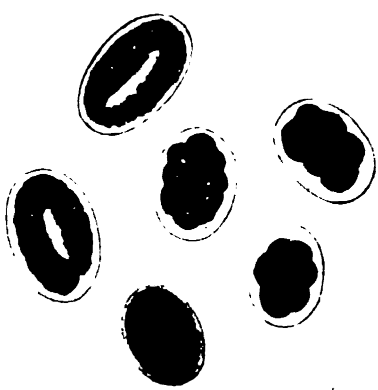

Fig. 4. *ANKYLOSTOMA CANINUM*
OVA OF
IN VARIOUS STAGES OF DEVELOPMENT
× 200 DIAMETERS.

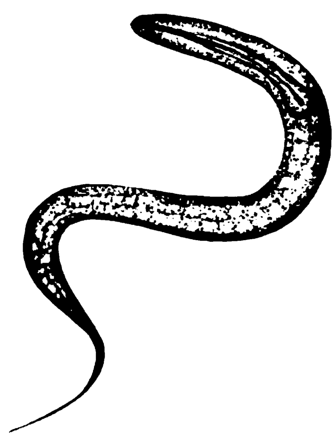

Fig. 5. LARVA OF *ANKYLOSTOMUM CANINUM*
72 HOURS AFTER INOCULATION ON AGAR
AT 20° C. × 300 DIAMETERS

infected his skin by a living culture, to demonstrate that the larvæ penetrate the skin, enter a small vein, are carried to the right side of the heart, and thence by the pulmonary artery into the lungs. Through the walls of the pulmonary capillaries they escape into the alveoli of the lungs, from which they migrate by their own gliding and lashing movement up the bronchi to the glottis, and then pass down the œsophagus and stomach into the duodenum and jejunum. Having reached this portion of the intestinal canal, the larvæ, having in their course become more and more matured, attach themselves to the lining membrane of the bowel. It takes at least three days for the larvæ to pass through the skin and by the blood stream, respiratory passages and œsophagus to reach the intestine. In passing through the skin they set up considerable irritation both in man and in the dog. It is thus that are to be explained the peculiar eruption of small boils on the arms of the Cornwall tin-miners known as "bunches," and the sores and boils on the feet and legs of coolies working with their bare feet in the tea plantations in India and Ceylon, and in the fields in tropical countries. It is difficult to say why the larvæ of the ankylostoma pass so frequently by the skin. They may possibly find in the intercellular fluids and in the liquor sanguinis something that aids their transformation into the mature worm, but, so far as we know, there is no difference between the fully developed worms whatever their mode of entrance.

Symptomatology.—Men who are the subjects of ankylostomiasis usually complain of extreme weakness, difficulty of breathing on slight exertion, fluttering of the heart, uneasy sensations at the stomach, and swelling of the feet which prevents them walking. They are worse in the summer than in the winter. This periodic character of the complaint is extremely interesting. On the approach of winter I noticed in my experiments upon canine ankylostomiasis that not only did the number of ova in the stools become diminished, but the ova themselves were if anything smaller and did not so readily develop into larvæ. The larvæ, too, were feebler. The dog which passed the ova improved in condition on the advent of the colder weather. On the approach of summer the ova

became more numerous and the larvæ more active. This cyclical condition of things is not peculiar to ankylostoma. I have observed the same in an infant who was passing live maggots by the bowel. When the larvæ of ankylostoma, having penetrated the skin through a hair follicle, have reached the upper part of the small intestine, it is not until the ninth day that their hooks are developed, and not until four to six weeks (Stiles), 71 days (Looss), after their entrance into the body that they become fully matured worms capable of throwing off ova in the fæces. Although immature, they are yet capable of inflicting great damage. The administration to a dog of milk containing ankylostoma larvæ caused the animal to retch and to vomit, followed in a day or two afterwards by signs of gastro-intestinal irritation, diarrhœa, and a disinclination for food. In man the early symptoms are also gastro-intestinal, but owing to the mode of infection being in all probability more through the skin, or if by the mouth, then owing to the fact that very few larvæ have been swallowed, it is seldom that the symptoms are those of an acute gastro-enteritis. The intestinal symptoms largely depend upon the number of larvæ entering the alimentary canal, the idiosyncrasy and the health of the patient at the time. As repeated infections probably occur, the symptoms are slowly developed. Gradually digestion becomes impaired and there is induced anæmia. The pallor, which is at first slight, slowly increases, the pulse becomes feebler, the dyspnœa greater, and the feet more swollen. If in this condition the patient continues to remain in the infected area and incurs the risk of fresh invasion of his alimentary canal by larvæ, the symptoms will become progressively worse and death may take place. Where the possibility of re-infection is excluded and the malady is slight, the illness tends to wear itself out, for the individual cannot re-infect himself by the parasites in his intestine, except by ova passed in his stools developing externally into larvæ and some of these embryos accidentally gaining admission into his alimentary canal through food or drink. While anæmia and pallor of the body are the physical signs of the disease in miners, the coolies who work in the fields in the tropics suffer from an eruption on

their skin called "ground itch" or "water itch," a similar eruption to that on the arms of the Cornwall miners known as "bunches." In persons thus afflicted it is observed that when the skin becomes broken or is ulcerated it does not heal rapidly. Stiles found "pot belly" a frequent physical sign of the malady in young persons. The peculiar shape of the abdomen is due to an extremely distended state of the bowel from gas and the presence of free fluid in the peritoneal cavity. The feet swell and in advanced cases the urine may contain albumen. According to Zimm and Jacoby ("Report on Prevalence and Geographic Distribution of Hook-worm Disease," Washington, U.S.A., 1903, p. 68) the urine contains a poison or ptomaine, so that when the urine is injected into the vein of a healthy animal it causes destruction of the red blood corpuscles. The fæces may be neutral, alkaline, or acid. I have found that the transformation of ova into larvæ takes place quite irrespective of the chemical reaction of the stools. This transformation may occur in 24 to 36 hours. Fully developed larvæ of the *Ankylostoma duodenale* are not found in the recently passed stools of patients. When larvæ are thus found they are the immature forms of another parasite, usually the *Strongyloides stercoralis*, which is the cause of Cochin-China diarrhœa, and the fully matured worms of which often co-exist in the human intestine along with the ankylostoma. In fact, there are frequently present in infected miners more than one form of parasite in the alimentary canal, the differentiation of which rests upon microscopical examination of the various kinds of ova present in the fæces.

In some patients the bloodlessness or anæmia is very pronounced. The degree of anæmia is generally, but not always, proportional to the number of worms in the intestine. The red blood corpuscles are reduced in number, and there is a marked fall in the amount of hæmoglobin or red colouring matter. The eosinophile corpuscles, a variety of the white, are usually increased in number. Instead of there being 5,000,000 red blood corpuscles in 1 cmm. of blood, there may be only 3,000,000 to 1,500,000; and the eosinophile corpuscles, which are normally present to the extent of 2 to 4 per cent. of the white corpuscles, may rise to 18 per cent. Any diffi-

culty of breathing experienced by the patient is largely the result of the diminution of the red blood corpuscles, which are the oxygen carriers to the system. Emaciation is in some instances very pronounced, and, while in some persons in the early stages of the malady there may have been a slight rise of temperature owing to a mild gastro-enteritis, the skin is usually cool. Infected subjects resist cold badly. The digestion is often impaired. There may be constipation, or alternating attacks of diarrhœa and constipation. In connection with disordered digestion it is frequently observed, especially in hot countries, that the appetite is perverted and there is developed a strong craving for indigestible substances, such as clay and mud. Opinions are divided as to the injurious effects of earth-eating. It is stated that the Javanese women eat it to improve their appearance. In Oronoco the natives eat earth brought down by the overflow of the river. Dirt-eating is not unknown in Africa. Stiles states that Alaskan seals, when infected with round worms, eat pebbles, and that elephants suffering from fluke-worm eat a particular kind of clay until diarrhœa is produced. Dogs infected with intestinal worms eat grass, and in hot countries children infected with thread-worm, *Ascaris lumbricoides*, eat dirt, a practice they desist from as soon as the worms are expelled. While earth-eating cannot be regarded as an absolute indication of the presence of worms in the intestinal canal, it appears to be a common practice both in man and animals, and is suggestive of some peculiar irritation being the stimulus to it. The practice should be discouraged, for there is little or no nutriment in the dirt, but possibly the ova of all kinds of parasites, whereby risks of fresh infection are incurred. Miners who are the subjects of ankylostomiasis do not exhibit to my knowledge this peculiar craving or geophagy.

Causes of Anæmia.—Since the fully developed ankylostoma attaches itself by its hooks to the mucous membrane of the intestinal canal, and when expelled is often observed to be gorged with blood, some writers have maintained that the anæmia is the result of the repeated abstractions of blood by the numerous parasites present in the alimentary tube. That this is a possible cause cannot be doubted, for when worms

are passed by the bowel after treatment it is not uncommon to find several of them choke full of blood, and at the post-mortem examination of one of my dogs who died from the disease I found several small bleeding and ulcerating points in the mucous membrane of the jejunum which marked the spots to which the parasites had been adherent. The worms apparently change their hold from time to time, and just as a leech-bite often bleeds after the animal has fallen off the skin, so the ankylostoma in detaching itself leaves a bleeding point behind, through which wound micro-organisms from the intestine may enter. Against the abstraction of blood theory it is stated by some writers that the amount of anæmia is not always proportional to the number of parasites present in the intestinal canal, but it is not always easy to determine beforehand the number of parasites even when vermifuges have been given. The severity of the symptoms must depend upon the number of worms present, the vital resistance, and the idiosyncrasy of the patient. The fact that in the liver and spleen of five persons who had died of ankylostomiasis in Fiji and Ceylon, Professor Stockman, of Glasgow (*Brit. Med. Journ.*, 1896, vol. ii. p. 189), found an extremely low percentage of iron rather suggests that a loss of blood had taken place and that this was the cause of the anæmia. Looss, of Cairo, on the other hand, maintains that the ankylostoma does not necessarily live upon the blood of its host, but upon the superficial cells of the mucous membrane and their secretions, and that the presence of blood in the worm is entirely accidental. In the act of sucking into its œsophagus the materials formed by the cells of the intestinal mucous membrane there is secreted by the small glands in the head of the ankylostoma a toxin or poisonous material which is absorbed by the host through the pricked mucous membrane. It is this toxin circulating in the blood of the host and causing destruction of the red blood corpuscles that by Looss and others is regarded as the cause of the anæmia. All the parasites that are found in the alimentary canal of man secrete substances that are more or less toxic. In addition the worms are frequently covered with the microbes that inhabit the intestine, some of which must gain an entrance

into the patient's body through the punctured wounds in the mucous membrane caused by the hooklets of the parasite. The presence of ankylostomes in the intestine, therefore, opens the door to secondary infection by micro-organisms from the alimentary canal, which induces such a serious state of body as to cause death.

The extension of the disease from an infected miner to his children is in Europe, as already stated, an uncommon occurrence. Cases, however, have been reported. M. O. Cozzolino (*Pediatria*, Février, 1907) found the disease in two twin sisters two and a half years of age, the children of an Italian miner in Genoa, who had recently arrived from Brazil, both of whom died. In the upper part of the small intestine in one there were found, at the autopsy, upwards of two hundred ankylostomes, and numerous small hæmorrhages in the mucous membrane. These children had all the appearance of pernicious anæmia: the red blood corpuscles numbered 2,600,000 per c.mm. of blood without any notable eosinophilia. During life the ova of the parasite had been found in the stools. As the parents with their family had only recently returned from South America, it is hardly right to regard the presence of the disease in the children as having been necessarily associated with the work of the father. It is more than likely that the ankylostomiasis was endemic in the place where they had lived.

Treatment of Ankylostomiasis.—The treatment of this disease is preventive and curative. As the presence of one infected careless workman in a mine may be followed by infection of that mine, experience has shown the desirability of mine-owners getting made for them a microscopical examination of the fæces of suspected miners and of men who have come from an infected district, since in our own country, apart from Cornwall, three or four cases of ankylostomiasis have been found among miners who have returned from India and elsewhere. The necessity of watchfulness is at once apparent. The ova of *Ankylostoma duodenale* do not hatch readily at low temperatures, but because the temperature of British coal-mines is usually lower than that of many of the pits on the Continent, and the ventilation of our collieries is considered to be better,

there is an idea that our coal-pits do not offer the conditions favourable to the development of the parasite. As a mining country we have no right to hug this belief, and close our eyes to the necessity of instituting watchful and preventive measures.

Dr. Lambinet, who is in charge of the Miners' Dispensary at Liége, found that the ova of ankylostoma could be hatched at temperatures lower than 60° F., and Haldane even as low as 48° F. I have kept ova in a cold cellar at a temperature of 50° F. for six weeks to two months, and yet at the end of that time found that the larvæ which developed were extremely strong and vigorous—in fact, it seemed as if the exposure to a low temperature had rather improved than diminished their vitality. This was not always the case, however, for after exposures to low temperatures the ova required fifteen days to change into larvæ. I have placed ova in freezing mixtures of ice, and kept them at 1° C. for more than an hour, and yet forty-eight hours afterwards the ova became transformed into larvæ. There is, therefore, no real security from ankylostomiasis because of the lower temperatures in British coal-mines compared with those of the Continent. The ova require a certain amount of water and oxygen. It is partly owing to the absence of oxygen and to the rather high temperature of the human body that the ova do not become transformed into larvæ in the alimentary canal, and yet on one occasion I exposed larvæ to a temperature of 99° F.—practically speaking, the temperature of the human body—for twenty-four hours, and on the following day they were still alive. In addition larvæ which I had put into an artificial gastric juice were, at the end of five days, still living and mobile.

Water-closets should be provided for the men at the pit mouth, and their use encouraged. In infected mines portable dry closets or covered iron pails should be provided for the use of the men working underground. The deposition of fæces by the men elsewhere than in the receptacles provided for this purpose should be made penal. The pails or receptacles should be taken out of the mine daily, rinsed with boiling water

and thoroughly disinfected. The miners should wash their hands well before eating. Instruction should be given to the workmen upon the life-history of the parasite, so as to secure their intelligent co-operation. Fresh miners, who have worked in tropical or mid-European countries, on applying for employment in British mines should have their fæces microscopically examined before being accepted. Free ventilation of the pits and a cool temperature therein are aids to prevention. At my visit to the Westphalian coal-mines I found Dr. Tenholt carrying out a series of experiments with antiseptics as to the possible destruction of ova and larvæ in one of the galleries of the Lothringen mine. The temperature was rather high. The sides of the gallery to the extent of 3 feet upwards, and the wooden props in a similar way, were being sprinkled with a strong solution of lime, but the results were not so satisfactory as had been anticipated. The resistance of the ankylostoma larvæ to disinfectants of all kinds is remarkable, unless the solutions used are of such strength as to become dangerous in their general application. It has been known for some time that mines into which salt or sea water has trickled exhibit a remarkable freedom from ankylostomiasis, while contiguous mines not so circumstanced are infected. Manouvriez, of Valenciennes, was one of the first to demonstrate this fact, which finds corroboration in the tin-mines of Cornwall. The Levant mine contains water in which sea salt to the extent of 2·72 per cent. has been found. This mine is free from the ankylostoma. Lambinet, of Liége, has carried out a series of experiments with salt water. If the larvæ are simply deprived of water alone—that is to say, undergo gradual desiccation—they shrink inside their capsule; and if the process of drying has been carried too far, it is impossible to reanimate the shrivelled-up larvæ. If, under the influence of exposure to a 15 per cent. solution of sodium chloride, the abstraction of water from the larvæ has not been carried too far, there is simply arrest of movement after twenty-four hours' exposure; but if the salt water is replaced by pure water, the movements gradually return and the larvæ are soon brisk again. A 30 per cent. solution of common salt

or strong glycerine causes such a retraction and withering of the larvæ that even when re-hydrated it is impossible to restore movement, for the larvæ have been killed owing to breaking up of their substance by plasmolysis. Lambinet submitted larvæ for twenty-four hours to solutions of chloride of sodium varying from 2 to 15 per cent. It was only at the higher percentage that the movements of the larvæ became impaired or ceased, and not until a 30 per cent. solution was employed that death of the larvæ was fully assured. The ova of the ankylostoma were destroyed by a feebler saline solution than the larvæ. A 4 per cent. solution of salt absolutely prevented the ova becoming transformed into larvæ: smaller percentages only retarded the transformation. In an infected mine the repeated spraying of the walls with concentrated solutions of common salt would be worth trying. This would be in pits an inexpensive method of getting rid of the pest, but to be successful strong solutions would have to be used.

Since the publication of Lambinet's experiments fresh support to the theory of the protective influence of sea salt solution in mines has been announced by M. L. Tirelli,[1] who is officially attached to the sulphur mines of Trezza Albini, Romagna. Tirelli noticed that some mines were free from the ankylostoma, while others, despite all precautions, regularly furnished a large number of cases. The geological structure of all the mines is the same. The mines that are free are the driest, but immunity from the parasite does not depend upon this circumstance, for there is plenty of moisture for the larvæ to live and thrive in. On examining the water Tirelli found that it contained different quantities of sodium chloride, varying in some mines from 0·009 per cent. to 19 per cent. in others, also that the mines in which the water contained 1 per cent. were infected, while those in which the water contained 2 per cent. and upwards were free. The fact that the ova of the ankylostoma cannot live in water containing 2 per cent. and upwards of common salt points the way along which infected mines may be cleared of the larvæ. The galleries must be sprayed with strong

[1] "Riv. d'Igiene e Sanita," published 19 Mars, 1907.

solutions of chloride of sodium, as recommended in the preceding paragraph.

In the treatment of patients by medicine reliance must be placed upon the internal administration of aperients and vermifuges. Of purgatives allusion need only be made to a few, such as castor oil, jalap, and calomel. Before giving intestinal antiseptics it is always well to clear out the bowels first and to put the patient on liquid diet for at least one day. In Westphalia I found extract of male fern was given by Tenholt; but in large doses, frequently repeated, he had noticed that it caused neuro-retinitis, and that in at least one case its administration had been followed by permanent blindness. The introduction of thymol by Bozzolo, in 1880, has placed in the hands of the medical profession a more reliable drug than male fern, and one, on the whole, safer if certain precautions are attended to. The efficacy of the drug depends largely upon the fact that it is insoluble in the alimentary canal, and is, therefore, capable of acting upon a considerable length of the intestine. Collapse and alarming symptoms have occasionally shown themselves after its use. Thymol, to be of any good, must be given in doses from 15 to 30 grains every two hours until four or six doses of the drug have been taken, when the bowels should be relieved by means of a purgative, unless previously opened spontaneously. The drug is best given in cachets, or in tablet form. It is extremely soluble in alcohol, ether, turpentine, chloroform, oil, glycerine, and some alkaline solutions, so that during a course of thymol treatment these agents should be avoided. When, in a patient who is taking thymol, the urine becomes dark brown in colour, and there develop such symptoms as delirium and vertigo, it is time to discontinue the drug.

Goldman, of Sopron-Brennberg, uses a compound which is efficacious, and which he calls ankyl.[1] In one of his patients, whom I saw with him, there were, as the result of a single

[1] Goldman also named the preparation taeniol. It is obtained from the rind of Mussenna Abyssinica, a Myrsinacea found in Persia. The active principle of the drug is not well known chemically: it is best given with thymol.

administration of the medicine given four hours previous to my visit, fully one hundred mature worms passed in the dejection. Beta-naphthol, eucalyptus oil, and areca nut, with a host of other drugs, have been tried. The proof that the treatment is doing good is the presence of the worms, dead or alive, in the stools. After discontinuing the antiseptic treatment for a week, the fæces should be again microscopically examined for ova, and, if present, the treatment must be renewed.

Since the presence of salt in the water trickling down the galleries of a mine is a preventive of ankylostomiasis, it has been recommended to replace the antiseptic treatment in the case of infected miners by common salt in large doses. Chloride of sodium in days gone by was regarded as a safe and reliable anthelmintic. It has to be given in large doses, say, half an ounce to three-quarters. Administered in the form of a concentrated solution, it loses to a great extent its power of being absorbed; it passes on into the intestine, where it acts as an aperient, causes detachment of the worm from the mucous membrane, and aids in its expulsion from the body. To prevent the absorption of the sodium chloride it is well to saturate the solution of common salt with bicarbonate of soda, *e.g.*, 6 drams of chloride of sodium, 2 drams of bicarbonate of soda in 5 to 6 ounces of water. Experiments upon animals that harboured intestinal worms gave good results with sodium chloride.

Notwithstanding all that is done in the way of medicinal treatment, a few ankylostomata often remain adherent to the intestinal mucous membrane and seem to be uninfluenced by drugs. It is thus that we seek to explain the fact that in a mine that has been infected, despite all the prophylactic and curative measures that have been taken, there still remain 5 to 9 per cent. of the men in whose fæces the ova can be found. The points that have struck me in regard to ankylostomiasis are the silent march of the disease from mine to mine and from one mining centre to another, the long latent period of its incubation, the suddenness of its outbursts, and the extreme virulence of the endemic when it first appears compared with what it is later on.

Anthrax, or Woolsorters' Disease

Anthrax, or woolsorters' disease, is an infectious malady due to the entrance into the body of a minute organism, the *Bacillus anthracis.* Discovered by Pollender in 1849, its life history was subsequently detailed by Pasteur, Davaine, and Koch. The organism clings to the hides of animals that have died from the disease or been slaughtered on account of it. The bacillus also attaches itself to wool and horsehair, and to pigs' bristles used in brush-making. The slightest scratch of the skin or the presence of a minute wound is sufficient when contact occurs for inoculation to take place, or the organism may gain entrance into the body by the inhalation of spore-laden dust or by food. Animals become infected mostly through food, man by other channels, such as the respiratory organs and the skin. As in infected animals the spleen becomes enlarged, the disease in them is often called "splenic fever." Although the cases recorded in history of the concurrence of *murrain* in animals and of disease in man may have been illustrations of anthrax, it was not until the latter half of the eighteenth century that anthrax in the human subject came to be associated with the manipulation of hides and fleeces used for industrial purposes. In 1769 Fournier, of Dijon, drew attention to the occurrence of the disease in men who were engaged in the handling of raw animal products, but it was not until a century afterwards that the malady received serious study. Lawrence, in 1847, described the disease as observed in a hair factory in England. Subsequently, owing to the large number of deaths among woolsorters in this country, men began to suspect that the deaths might in some way or other be associated with the nature of their employment. In 1879 Dr. John Henry Bell, of Bradford, when visiting a patient who had died twelve hours after the commencement of his illness, took blood from the man's arm, and after injecting some of it into a guinea-pig and mouse, found that the blood of these animals was swarming with anthrax bacilli. The association of woolsorters' disease with anthrax was thus definitely established (*Lancet*, 1879, vol. ii. p. 920).

For several years past anthrax has been at times a veritable scourge in Bradford and in the woollen districts of the West Riding of Yorkshire, where about three-fourths of all the foreign wool imported into this country is manipulated. The disease is met with, too, in Worcestershire. In the woollen districts of the South of England and of Scotland anthrax has been conspicuously absent, owing to the fact that only colonial and home-grown wool is manipulated in these places. In London and Liverpool anthrax is well known. Dr. T. M. Legge in his Milroy Lectures (*Lancet*, March 18, 1905) has gathered together nearly all that is known of woolsorters' disease. He states that during the six years 1899 to 1904 there were reported to the Home Office 261 cases of anthrax contracted in factories and workshops. Of these 88 occurred in worsted and wool factories, 70 in horsehair and bristle works, 86 in hides and skins, and 17 in other industries; 224 of the sufferers were males and 37 were females; 67 of the cases proved fatal. The disease has appeared mostly in the wool-sorting, wool-combing and spinning industries, in the manipulation of horsehair for stuffing chairs and mattresses, and in the preparation of bristles for brush-making. Anthrax has also been met with in persons employed in tanyards and in warehouses connected with docks. An idea may be formed of the importance of these trades by a reference to the number of persons employed in them. The wool, worsted, and shoddy industries of the United Kingdom gave employment in 1901 to 259,909 persons (106,598 males and 153,311 females), but of this number only 1,171 (1,164 males and 7 females) were engaged in sorting, and 3,093 (1,882 males and 1,211 females) in combing the dangerous wools. In horsehair factories according to a recent Home Office Report the total number of persons employed is 2,535 and in brush-making factories and workshops 611 and 11,753 respectively. Of the two industries wool and horsehair it is found that persons employed in horsehair are the more liable to the disease. The percentage of cases of anthrax in bristle works is small. The danger resides in the handling of the hides and fleeces of infected

animals; hence the occurrence of the disease in farmers and farm labourers, butchers, and meat inspectors. Dusty wools and "fallen fleeces"—*i.e.*, fleeces of animals that have died from anthrax—are the most dangerous. According to the method of infection in man, so is the type of the disease. The mode of infection is largely determined by the nature of the employment. Anthrax is a general disease when the bacillus or its spores have gained access to the blood-stream, or it may give rise to a local red and painful swelling called "malignant pustule." Of these the former is the more dangerous since it implies a widespread infection of the system. In Newcastle-upon-Tyne anthrax in any other form than malignant pustule is hardly known. My own experience of the disease is drawn from its limited manifestations in the form of pustule on the cheek and neck of butchers and cattle salesmen. These are the parts of the body most liable to be affected, but the arms and fingers are by no means exempted. In addition to the pustular form there occurs an erysipelatous type which is known as malignant œdema.

It is estimated that there are about 1,000 cases of anthrax in animals annually in Great Britain; but this is only one-fourth of what occurs in Germany and Italy, while in European Russia and the Caucasus the number of cases is probably 40,000 a year.

In this country anthrax is more frequently due to the entrance into the body of the spores of the *Bacillus anthracis* than the fully developed organism, which usually infects man direct by handling the carcass of a dead animal. The disease comes into Britain with the wool from Persia, hair and van mohair from Asiatic Turkey, with horsehair from China, bristles from Siberia, and dry hides from India and China. It is from Asia that most of the infected material comes. There, many of the people still lead a wandering pastoral life, and are indifferent to all the requirements of hygiene as affecting either themselves or their cattle. Stagnant water in which soiled fodder has been allowed to decay forms, when it becomes alkaline, a suitable medium for the growth and reproduction of the anthrax bacillus. The micro-organism

flourishes in low, marshy lands, where organic matter is undergoing putrefaction in brackish water, in river valleys, in the salt grass Steppes of Siberia, and also on lands that are flooded in winter and are dry in summer. The bacillus grows best between a temperature of 12° C. (53° F.) and 40° C. (104° F.). In countries where the winter is severe and the summer heat is excessive, as in the central plateau of Asia Minor, with its numerous salt and fresh water lakes, where roams the Angora goat on the plains and are herded innumerable flocks of sheep, there anthrax flourishes, and there, too, occurs the contamination of the hides and wool owing to the dirt and sand, which contain the spores of anthrax, becoming adherent to the fleeces and the long hair as these are trailed along the ground. That the soil and pasture become contaminated, can harbour the spores, and cause infection has been shown by placing the manes of animals that died from anthrax upon the fields and allowing healthy animals to graze thereon, or, as occurred in the case of two horses that consumed the grass in a field close to a woollen factory in Yorkshire, in 1901, and upon which had been blown dust from Persian wool that was being cleaned in the factory. Silberschmidt mentions outbreaks of the disease near Zurich, in which eight out of twenty-two animals became infected by dust blown from the chimney of a horse-hair factory (*Zeitsch. f. Hygien.*, vol. xx. p. 455). Legge, in his Milroy Lectures, alludes to other instances, and draws attention to the relationship of outbreaks of anthrax and the factory conditions prevailing at the time. Ravenhal, of Pennsylvania, instituted an inquiry a few years ago into the part played by tanneries in spreading the disease among cattle fed upon pastures that were watered by streams contaminated by tannery refuse, and he found that there had died of anthrax sixty cattle which had been grazing near the tanneries. In factories a considerable quantity of dust is given off during the opening of the packages of wool, also during the sorting, blending, and cleansing of wool that has been neither washed nor disinfected. The long hair used for weaving purposes may have been previously soaked in warm soda solution ; but China mane hair and bristles are only subjected to a process

of dry heckling through steel pins before being used in manufacture. In the woollen factories of Bradford I have been struck by the good effects that have followed the introduction of exhaust ventilation at the sorting tables, whereby the dust is at once removed downwards and away from the face of the worker when the bales are opened; and yet this and the running of fans have not always prevented the occurrence of the disease. When, perchance, something has gone wrong with the machinery and methods of ventilation, cases of anthrax occur unexpectedly.

New Zealand and Australian wool does not cause anthrax, as a rule, owing to the disease being less prevalent in the Colonies and the exercise of greater caution in the disposal of the carcases of infected animals. Dr. Bell, of Bradford, was of the opinion that the worst wools are those which are dusty and contain little "yolk," *i.e.*, the unctuous substance, a "kind of potash soap which pervades the wool and protects the animal from the effects of rain and cold; it also nourishes the wool, rendering it soft, oily, and pliable." The yolk is equal in weight to 7 or 8 per cent. of the "raw" fleece. When the yolk is abundant Bell considered that it fixes the anthrax spores, and renders the wool not so harmful to the sorters through being less dusty. There is not the least doubt that in woolsorting dust is the principal danger. W. H. Hamer has pointed out that although infection from wet hides is infrequent (article "Anthrax" in "Dangerous Trades"), the presence of moisture in hides favours the development of anthrax spores into bacilli. In this fully developed form the micro-organism does not live so long as the spores. The substitution of wet for dry hides would tend to lessen the risk of anthrax in persons handling the hides. The manipulation of dry horsehair has on several occasions been followed by an outbreak of the disease. In 1879 there occurred nine cases of anthrax in persons who had manipulated infected Russian horsehair, and of these seven died. Experience has shown that anthrax can be averted by disinfecting horsehair with steam under pressure. In Germany industrial problems such as the one we are discussing are dealt with in a manner which we cannot but admire. Not only have public disin-

fecting stations been erected, where wool and hair can thus be dealt with, but there is a Government regulation to the effect that "all foreign horsehair, cowhair, or goathair, pigs' bristles, and wool, before they are manipulated in the factory shall be disinfected at the choice of the occupier in one of the following prescribed ways:—

"1. By the action, for at least half an hour, of current steam at 0·15 atmosphere above atmospheric pressure (about 17 lbs., and equivalent to a temperature of 220° F.).

"2. By boiling for at least a quarter of an hour in a 2 per cent. solution of potassium permanganate, and subsequent bleaching in a 3 to 4 per cent. solution of sulphurous acid.

"3. By boiling in water for at least two hours."

In his Report on Anthrax (1906) Dr. T. M. Legge states that experiments carried out at the Imperial Office, Berlin, have shown that so long as the pressure does not exceed 2½ lbs. above atmospheric pressure, equivalent to a temperature of 220° F., long hair will suffer no damage. Curled hair can be submitted to higher temperatures. The adoption of these and other means of disinfection would materially reduce the risk from anthrax, if it did not abolish the risk entirely.

Symptomatology.—The effects of the entrance of anthrax bacilli or spores into the human body may be local or general. When local the disease causes a hard, red swelling, known as "malignant pustule," usually situated on the face or neck, and which, if seen early by the surgeon, can be excised with success, for at this stage of the malady the bacilli multiply slowly at the point of inoculation, and the organisms are not found in the blood. Around the margin of the pustule there are signs of inflammatory œdema, of a reactionary nature, which is a protective barrier to the system. If the organism effects an entrance it can only be by rather a roundabout path, for the lymphatic glands are likely to offer obstruction. General infection of the system can only occur after the cells of the tissues at the local point of infection have become weakened in their struggle with the bacilli or when their protoplasm has become poisoned by the toxins formed by the micro-organism. The patients with malignant pustule operated upon in the Newcastle Infirmary made, with

one or two exceptions, a satisfactory recovery, showing that up to a certain point the disease is local. Excision of the pustule is almost sure to be followed by disfigurement, but this possible result must not be allowed to weigh against the risk to life by leaving the pustule alone. In the erysipelatous form of anthrax, or malignant œdema, as it is sometimes called, the appearance presented by the patient so closely resembles that observed in ordinary erysipelas with œdema that the one disease might be readily mistaken for the other, were it not for the fact that there is less constitutional disturbance in malignant œdema. The detectionof the *Bacillus anthracis* in the culture made from serum withdrawn from the affected part would settle the diagnosis. The erysipelatous form of the malady is more fatal than malignant pustule.

When the tissues over a considerable area around an anthrax pustule on the face or neck become inflamed and œdematous, the half of the face or neck affected assumes enormous proportions, and the patients complain when the neck is swollen, as if they were being choked. One patient whom I saw in this condition, and who was perfectly rational at the time of my visit, whose pulse-rate was 122 per minute, temperature 103°, and whose lungs and heart were healthy, suddenly became delirious a few hours afterwards, ran up and down the Infirmary ward, and ultimately shut himself up in a room in a state of frenzy. This outburst of acute toxic delirium was followed by extreme exhaustion, and shortly afterwards by death. This patient had received serum treatment, but it was of no benefit to him.

Woolsorters' disease is the pulmonary form of anthrax. It was observed in sorters of alpaca and mohair in Bradford as far back as 1846. Since then it has been met with in persons who manipulate camels'-hair, Persian hair, and dusty foreign wools, owing to inhalation of the anthrax spores in the dust given off by these animal products. Although anthrax is extremely fatal when the micro-organism has invaded the system through the lungs, the absence of acute, severe, and painful symptoms from the commencement of the illness until death is noteworthy. There is none of the severe rigor nor of the shivering which so frequently ushers in

acute infectious diseases. If there is shivering, it is slight; it is more a sensation of chilliness that is complained of than anything else. Pain, cough, vomiting, and diarrhœa are not prominent features. An uncomfortable sensation at the pit of the stomach is often complained of. Although there may be little cough, the breathing is embarrassed, and there is a sense of tightness and oppression about the chest. Expectoration is not abundant, and only occasionally is it rusty-coloured, as in pneumonia. On percussing the chest-wall slight dulness may be detected over the base of one lung, usually the right, and on auscultation the respiratory murmur is feeble, or it is attended by moist bronchial râles and crepitations. Subsequently the physical signs suggest the presence of fluid in the chest. The pulse is feeble and the heart's sounds are weak. The skin presents a dusky appearance, and is cold to the touch; the patient exhibits signs of collapse. With all this the mind remains clear to the last, or the patient dies in a state of coma, with or without convulsions. The urine is scanty, and often contains albumen. Pyrexia is not a prominent feature. Should a rise of temperature to 103° F. occur, it generally betokens widespread infection or a septic pneumonia. In the pulmonary form of anthrax death generally comes any time from the second to the fourth day. The characteristic feature of this form of the malady is the rapidity with which collapse sets in. After death the body decomposes very rapidly. There is extensive livid discolouration of the skin of the face and neck, of the skin of the trunk and posterior parts of the body, and on incising the skin of the chest-wall bubbles of air escape, owing to the existence of subcutaneous emphysema and commencing gangrene. In the pleural cavity there is usually some straw-coloured fluid. A thick layer of gelatinous material covers the lungs, which on section are found to be gorged with black fluid blood, with here and there small patches of red consolidation or hæmorrhages. The bronchial glands are enlarged. On the surface of the heart and in its substance are numerous petechial hæmorrhages. In the abdominal cavity there is gelatinous-looking fluid. The spleen may or may not be enlarged. On examining the brain hæmorrhages may be

found underneath the membranes. The post-mortem appearances are consistent with the fact of some profound impression having been made upon the blood whereby the nutrition of the small blood-vessels is destroyed and there occur as a consequence numerous minute hæmorrhages. In the brain of a woolwasher (Russian camel-hair, Persian wool, &c.), aged forty-eight, kindly sent to me by Dr. F. W. Eurich, of Bradford, there are numerous hæmorrhages under the pia-arachnoid membranes. The illness began with a small pimple on the man's wrist on February 25, 1907, but it was considered so trifling that medical advice was not sought until February 27th. The bacilli of anthrax were then found in the serum of the pustule. An hour or two afterwards the pustule was excised, and 80 cc. of Sclavo's serum injected during the course of the next forty-eight hours. The patient never responded to the treatment, but became delirious and violent, and died on March 1st in a state of coma. At the autopsy numerous hæmorrhages were found in the lungs and extensive hæmorrhages on the brain. The case is a good illustration of an infection extremely limited in the earliest instance being rapidly followed by a general infection and death.

Treatment.—The treatment of anthrax is preventive and curative. So far as curative measures are concerned, extirpation of the malignant pustule when the disease is entirely local gives good results. The hypodermic injection of a small quantity of a 2 per cent. solution of carbolic acid into the tissues immediately surrounding the pustule has sometimes proved satisfactory, but removal of the pustule is preferable. It is when we have to deal with the pulmonary form of the malady that we find we are face to face with a disease that resists ordinary medicinal treatment. The recent advances of serumtherapy have placed in our hands a powerful and fairly reliable remedy. Sclavo, of Milan, has introduced an anti-anthrax serum which, when early adopted, has been followed by marked success. Sclavo published all the cases of anthrax treated by serum up till 1903. Of 164 thus treated 10 died, equivalent to 6·09 per cent., compared with 24·1 per cent. for the whole of Italy. Since July

1904, the serum treatment has been tried in England either alone or in connection with excision, in 12 cases of external anthrax. In 4 of these 12 cases serum alone was used—one of these, which was far advanced before the serum was adopted, died. Strong testimony to the efficacy of the serum treatment comes from Santa Croce, a small town on the Arno. Here 36 tanneries give employment to 350 persons. Among the workers who manipulate China hides anthrax has been frequent and fatal. So convinced are the workmen of the beneficial effects of the serum treatment that they insist on having it to the exclusion of all other means. The peasantry of the district around Siena when ill often make their way into that town voluntarily to receive treatment. The immunity conferred upon sheep and cattle by injecting into them anti-anthrax serum is now a recognised fact. The result of a series of experiments carried out by Sobernheim confirms the opinion expressed by Sclavo that the use of anti-anthrax serum is free from danger and is very effective, that it protects the animal from all forms of anthrax, including the intestinal, and that it can be used for curative purposes in man with safety. The inoculation treatment of infected persons by serum, specially prepared on the lines recommended by Sclavo, gives promise of great success, and ought to be tried early in every case of the pulmonary form of anthrax—which has hitherto been defiant of all medicinal treatment.

While the disease is to some extent prevented by the bales of wool and hair being opened in wool and hair sorting factories in closed spaces with strong draught removing the dust away from the workers, not less than 75 cubic feet of air per minute being thus drawn away by the fan, it is advisable to disinfect the material first. Dusty and dangerous wools, such as van mohair and Persian, require to be thoroughly steeped in water in the bale before being opened, and the bales are only allowed to be opened by experienced workmen who have some skill in discerning flaws in the material. In steam we have a means of disinfecting hair which deserves to be given a trial. To be effective, as Dr. Legge, in his "Report on the Incidence of Anthrax," 1906,

says, "The steam must be in contact with the material in a loosened condition for a sufficiently long time and at a sufficiently high temperature, but in order that the material may not be injured this temperature must not exceed certain limits." Further, the conditions in which the steam is used, whether saturated or superheated, as current or confined steam, largely determine its efficiency. "To obtain the best results formation of moisture in the steam in contact with the material to be disinfected is necessary, the steam should be subjected to a slight degree of pressure, and the steam be allowed to stream through the apparatus until the air has been wholly expelled from the chamber. . . . Disinfection is brought about by the steam coming into contact with a colder surface, on which it condenses, and in so doing it gives up its latent heat (sufficient to raise from fifteen to sixteen times its own weight of wool from 0° F. to 212° F.)." Anthrax spores are not so readily destroyed by heat as are the fully developed bacilli. In the experiments carried out in Berlin it was found that even long hair exposed to steam under a pressure of 28 lbs. above atmospheric pressure, equivalent to a temperature of 220° F., suffered no damage for manufacturing purposes and sale. Since the enforcement in Germany of the regulation introduced in 1899 requiring that hair shall be boiled for at least two hours in water or for a quarter of an hour in a 2 per cent. solution of potassium permanganate, with subsequent bleaching in a 3 to 4 per cent. of sulphurous acid, the number of cases of anthrax in that country has markedly diminished. In England higher steam pressures have been used than in Germany, and with success. Boiling or disinfecting by steam the suspected material can, on the whole, be relied upon as likely to confer security upon the workmen, but for success to be attained attention to minute details is necessary.

In the Draft Regulations recently issued by the Home Secretary (May, 1907) *re* anthrax in the use of horsehair, it is stated that arrangements will be made whereby a large proportion of the horsehair can be disinfected by or for the importers before distribution to the manufacturers. This disinfection of the material on its entrance into the country

ought to be followed by good results. All horsehair should be disinfected except the white and light grey hair, which might suffer damage in the process. The Home Secretary has excluded bristles from the order, but although excluded from the Regulations the hope is expressed that when the disinfecting apparatus is installed manufacturers will adopt the practice of having undressed bristles also disinfected. Between January 1, 1906, and March 31, 1907, there were seventeen cases of anthrax, including six deaths, in connection with horsehair and bristles.

Hospital Nursing

The hospital, private, and district nurse has come to stay. As to the utility and helpfulness of the trained nurse there can be no question. But for her assistance medical and surgical skill would be robbed of much of its power for good. Attractive to women as hospital and private nursing is, the work is at times anxious and trequently fatiguing. The hours are often long. Many nurses after being on duty in the wards of a hospital all day are thoroughly tired at night, and their feet are tender and swollen. If the hospital is so placed that the nurses can sleep in good air a short distance from the hospital and in quiet surroundings, the gain to health and fitness for work are noticeable. Only strong, healthy, and well-developed women, with a distinct love for the work and sympathy with suffering, should undertake the duties of a hospital nurse, for there is much to try their patience and temper. Their feet should be good. As a consequence of spending the greater part of each day in infirmary wards which are not always too well ventilated, many nurses suffer from what is known as "hospital throat." Occasionally the sore throat becomes septic. Nurses who are in attendance upon patients with infectious diseases, such as scarlet fever, may become the victims of infection ; others who are looking after septic cases may through a small wound on their finger become infected and suffer from blood-poisoning. There is the risk, too, of tuberculosis. The records of hospitals for the treatment of consumption, also of sanatoria, do not show

that the nurses employed therein suffer from tuberculous phthisis in larger proportion than those engaged in general hospitals, a circumstance to be explained by the extremely well ventilated condition of these buildings, and the care that is taken in collecting the sputum and rendering it antiseptic before disposing of it.

What has been said of hospital nurses applies almost equally to house physicians and house surgeons in infirmaries, with this exception, that since these officers are not spending the greater part of the day in the wards they are less likely to incur many of the commoner risks which the nurses run, but are more exposed to the accidental dangers of blood poisoning in the treatment of abscesses and foul wounds in operations.

CHAPTER XII

DANGERS ATTENDANT UPON THE GENERATION AND USES OF ELECTRICITY AND ELECTRIC WELDING

Electricity

THE generation of electricity for lighting and for motor purposes is not an unhealthy occupation, but it is an extremely dangerous one, since the slightest contact with a live wire highly charged or a live part of the machinery is frequently followed by immediate death. In 1906 there were reported 199 electrical accidents in factories alone, and of these eight proved fatal. In generating stations there is elaborate machinery for the conversion of mechanical into electrical energy. The current formed may be immediately distributed or stored, or it may be transformed in the appliances of a transformer station, whereby small currents at high pressure are converted into large currents at low pressure, or *vice versâ*, and where direct and alternating currents can be also dealt with. "The currents produced by dynamos are classed as low pressure, high pressure, and extra high pressure. Currents at low pressure distributed from generating stations are invariably direct. High-pressure currents are distributed either as direct or alternating" ("Dangerous Trades," p. 252, Sir Hamilton Freer-Smith). Electrical experts differ as to what are the limits of safety for pressures. It was the opinion of the Dangerous Trades Committee of the Home Office, which investigated this subject, that currents at 700 volts direct and 350 alternating should be regarded as dangerous. American experts regard only such high voltages as 1,500 as dangerous. This was the amount they recommended to be used in the execution

of criminals, but even with this voltage it has occasionally happened that the heart of the electrocuted criminal began to beat again and respiration to be restarted, so that a fresh electrical contact had to be made. The result in every instance depends upon the manner in which contact with the live metal is made. If the skin is moist and unprotected, if the person is wearing damp boots and standing upon an earthed metal plate, these conditions tend to magnify the effects produced by contact, so that a direct current of 250 volts, and even less, may prove fatal. In Great Britain there have been several deaths from electric shock, but considering the extent to which electricity is used, and its increasing employment, it is astonishing that there have not been more fatalities. At the electrical stations of electricity supply companies throughout the country there were in 1906 39 accidents, 2 of which were fatal: in private electrical generating stations, 14 accidents, none of which proved fatal. In factories and engineering works, &c., there were in 1906 199 accidents, 8 of which were fatal. This is a considerable increase in the number of accidents in factories and engineering works over those of the previous year, viz., 199 as against 122, or an increase of 60 per cent., with 8 fatalities as against 4 in 1905. It is not always easy to get workmen to appreciate the dangers incidental to their calling. Since, for example, the cleaning or repairing of "live" switchboards is a cause of fatal accidents, this ought to be done when the pressure is off. There is no occupation, unless it be that of the manufacture of explosives, in which it is more desirable to employ healthy, well educated, careful and capable men, to whom the dangers of the occupation should be pointed out, than in the generation and distribution of electricity. There is no proof that one person is more susceptible to electricity than another. It is entirely a question of mode of contact and how the current enters the body. Accidental contact may occur with any person, but even fatalities from accidental contact can be diminished by the exercise of care based upon knowledge of the danger. Faulty construction of switches and installation of cheap machinery are often causes of burns. Opinions are

divided as to whether high-pressure alternating currents are more deadly than direct or continuous. It has been stated that alternating currents are twice as dangerous as the continuous, but this requires confirmation. The continuous current at high tension causes burns and considerable destruction of the tissues, but if the shock has been severe it causes death. With alternating currents burns also occur, but they are usually less severe, and the destruction of the tissues is less. D'Arsonval maintains that the continuous current is only risky to life when the circuit is broken, but other experts state that while the shock may be greater when the circuit is broken, closure of the circuit is not free from danger. One consequence of contact with high electrical currents is burning. The wounds inflicted are deep, irregular, and are apt to slough, and while the burned part is insensitive to pain, the surrounding parts, owing to their being in a state of inflammation, are extremely sensitive.

To the dangers attendant upon using electricity for lighting and heating purposes must be added those of the live rail. As a means of locomotion electricity is destined to play an important part in the future of railway travelling. It is freely used by the North-Eastern Railway Company on some of the local lines in and around Newcastle-upon-Tyne, and for a considerable time after its introduction it was a cause of death to men and children, as well as to animals that had strayed upon the line and had accidentally touched the live rail. Dogs are still slaughtered by it, and occasionally a fox gets killed. I saw on two or three occasions, with Dr. Alfred Wilson, of Wallsend, a man who had accidentally touched with one foot the elevated rail, which was charged with electricity. He immediately fell. Fortunately the accident was witnessed by a signalman, who left his box and rendered assistance. The injured man was removed from the rails in a state of coma attended by convulsions. For a few hours after reaching home he remained unconscious. When I saw him two days after the accident there were extensive burns on his head and a wound with blisters on the sole of the right foot. Within a few days the wound on the foot had sloughed so that

the bone of the big toe was exposed. The bone ultimately became necrosed and had to be removed. What struck me about the wounds inflicted by the live rail were their severity and the red, angry look they assumed. A month after the injury the wounds were irritable, painful, and not disposed to heal. An interesting point, too, in this case was that the man's foot had been literally split without the boot he was wearing showing the slightest injury.[1]

Dangers to life incidental to the use of electricity was one of the subjects referred to the Dangerous Trades Committee of the Home Office. As a member of that committee I felt that before expressing my personal opinion upon the matter it was desirable to know how death was brought about in electric shock. I submitted dogs to the influence of electric shock (*Brit. Med. Journ.*, January 15, 1898), and I concluded that death was due to sudden arrest of the heart's action. The immediate effect of passing high electrical currents through an animal is to throw the whole body into a state of extreme muscular rigidity, as in opisthotonos. On breaking the current the respiration becomes quicker and deeper than before the contact and the beat of the heart gradually returns to the normal. It occasionally happened that in a dog apparently killed by electricity the heart's action would entirely cease, no beat could be heard nor pulse felt, and yet, although to all appearances dead, the animal would bark loudly for a minute or two, the heart never again beating. Theoretically it is usually thought that it is the respiration that is first affected and that death in electric shock comes from the respiratory centre. Such was not my experience, and in this I am supported by Professor Prevost, of Geneva University, and by his assistant, Dr. Battelli, whose experience is that no matter whether the direct or alternating current is used, death is the result of the heart becoming paralysed. With high voltages, *e.g.*, 550 volts, the beat

[1] In a "Return" presented to the House of Lords, August, 1907, of the number of persons injured by "live rails" on 11 electrified railways, there occur the following figures. In 1904 there were 8 persons killed and 20 injured; 1905, 2 killed and 18 injured; 1906, 4 killed and 21 injured; and for 8 months, 1907, 2 killed and 12 injured. Total, 1904 to August, 1907: 16 killed and 71 injured. Of the 16 killed, 12 were trespassers and 4 were railway servants.

of the heart of an animal might become suddenly arrested by one shock, and after suspension of the respiration for a few seconds the breathing might again return for a short time, then gradually become feebler and feebler until life came to an end. When a man receives an electric shock and is not rendered unconscious by it, terror may cause him to faint.

Opinions as to the cause of death in electric shock other than those just mentioned have been published. Grange (*Lancet*, August 20, 1904) attributed death to hæmorrhage into the medulla oblongata, which by pressing upon the pneumogastric nerve induced respiratory failure and arrest of the heart's action. D'Arsonval believes that in the strong local effects which are produced, not only are the physiological properties of the tissues destroyed, but the local conditions reflexly and indirectly cause inhibition of the respiratory and cardiac centres. Of the two main views as to the cause of death that are generally advanced, respiratory arrest or cardiac failure, I lean to sudden stoppage of the beat of the heart. From what has just been said it is clear that the mechanism of death in electrocution is still a matter of dispute. It is possible that electrocution only causes apparent death, and that the real cessation of life is brought about by want of proper care and effort to set going again the beat of the heart and the play of the lungs. In death after electric shock Jellinek, of Vienna, found on lumbar puncture evidence of extremely high cerebro-spinal fluid pressure.

As already stated, electrical currents produce varying effects upon the human body, according to the manner in which they enter. A dry skin is a bad conductor. With a low voltage and good contact the muscles are thrown into a state of extreme rigidity. It is this muscular spasm which renders it impossible for a man to relax his grip of a piece of metal charged with electricity. The effects of electrical currents are only experienced when the currents enter and leave the body, and not when the circuit has been closed. The making and breaking of the contact are the periods when there is danger. The pain felt by men in non-fatal electrical accidents is due to the violent muscular contrac-

tions compressing sensory nerves or to the action upon the nerve endings of the products of electrolytic decomposition.

When an animal is mortally struck by electricity a cry is frequently uttered. The same occurs when a workman becomes the subject of a severe electrical accident. It is the cry that draws the attention of fellow-workmen to the spot where lies the apparently lifeless body of a comrade. The face is pale or it is cyanosed, the heart can no longer be felt beating or the pulse, the pupils are dilated, and mucus keeps oozing from the mouth and nose. Considerable care has to be exercised in removing the body from its contact with the live metal.

One of the important facts revealed by my own and others' experiments is that while death in electric shock, in all or nearly all cases, comes from sudden arrest of the heart's action, yet immediate resort to artificial respiration will in many instances restore an apparently dead body to life again. This I have succeeded in doing on several occasions, and it has been shown by practice, in the case of workmen apparently killed by electricity, that once contact with the live metal has been broken nothing succeeds better in restoring men to life again than artificial respiration immediately begun, and continued until breathing is established, or for such a length of time as to leave no doubt that life is quite extinct. One of the dangers and difficulties to workmen attempting to rescue an injured comrade is that the live wire or cable may still be grasped by the hand of the victim, so that it is dangerous to seize any part of the body, even the clothes, if they are damp. An attempt to remove the body of a workman suspended from the wires of an electric street lamp in Boston, U.S.A., was the cause of the death of the rescuer. If the clothes upon the body are damp there is always danger. Whenever any rescue work is being attempted indiarubber gloves should be worn, and if these are not available the hands of the rescuer should be wrapped in thick dry rags before trying to pull the victim away from the cable or machinery. When removed the body should be placed upon its back, and while medical assistance is being sent for no time should be lost in putting artificial respiration into practice. Kneeling behind the head of the injured

person, the operator should grasp the elbows and draw them well over the head, so as almost to bring them together above it, and hold them there for a few seconds; then, carrying the arms down and on to the chest, firm compression of the thoracic wall should be made, so as to displace the air in the lungs. The movements should not succeed each other too rapidly, but ought to imitate nature as far as possible, *i.e.*, about sixteen times per minute. Stimulants should on no account be poured down the throat of the victim nor even placed in his mouth. If life is to be restored at all, it will only be by artificial respiration carefully and methodically carried out, not too hurriedly, as already advised, and persisted in for a considerable time—half an hour or even longer.

After death in electric shock the blood is generally found dark and fluid, but occasionally I found it clotted in the right side of the heart. On spectroscopic examination the blood may be found to contain oxyhæmoglobin and reduced hæmoglobin. The lungs present nothing abnormal, unless a few ecchymoses if artificial respiration has been rather vigorously attempted. The pupils are usually dilated. The brain and spinal cord may be congested. There may or may not be marks of burns upon the body.

The voltage used on railways varies from 300 to 600 volts. This is allowed by the Board of Trade, the opinion being that it is not dangerous, but contact with lower voltages than these has caused death on several occasions. In all cases the circumstances in operation at the time have to be considered. It is known that the risk to railway men is increased in wet weather. The danger consists in one part of the body, *e.g.*, the foot, touching the live rail while the other is on the wet earth. The elevated rail ought therefore to be protected as far as possible to prevent accidents taking place.

Electric Welding

In the electric welding of metal, a method that is becoming extensively used in ironworks, the light produced is so intense that it cannot be looked at by the naked eye even

for a second, yet it is necessary for the workmen to follow the process closely and to direct the current sometimes at one point, sometimes at another, as the work proceeds. For this purpose the workmen wear spectacles of smoked glass or, as in Sheffield, shields composed of alternating layers of blue and red glass. The heat evolved in electric welding is so intense that the metal submitted to the process is almost immediately liquefied. In addition to the risk to the eyesight, the skin is apt to become red and hot, as if acutely sunburnt. The reddening of the skin does not appear to be due to the high temperature, for the heat generated does not radiate very far, but is more probably the result of a combined electrical and chemical action of the light rays, such as occurs with the Röntgen rays. In some of the Sheffield steel works, Mr. Simeon Snell says, the men, in order to protect the head and face, wear a helmet in front of which is a glass window made up of red and blue glass. Exposed parts of the body get immediately burned, and should perchance the eyes "catch" the light the effects may not be felt immediately, but some hours afterwards. The eyelids swell and the men complain of their eyes feeling sore. Fortunately the symptoms, which are attended by an excessive secretion of tears, only last in most instances for 24 to 36 hours. Snell is of the opinion that the effects of the light are confined to the conjunctival and corneal surface of the eye, but in some instances I have been informed of temporary blindness associated with vascular changes in the optic disc and retina. Electric welding is work which no man with weak eyes ought to undertake without first being warned of the dangers and without having his eyes examined by an oculist. It has not been exactly determined whether it is the heat or the chemical rays of light that are hurtful to the eyes. The heat is excessive and is with difficulty measured, but it may rise to 7,000° F., while the luminosity, according to Mr. Simeon Snell, may be equal to 8,000 candle power.

M. Crzellitzer (*La Presse Médicale*, December 8, 1906) reports the occurrence of several cases of "electrical ophthalmia" simultaneously in a group of workers employed in

a factory in Berlin where steel rails were fused by means of electrical currents. The work was being carried on in the angle of a small court through which, on one particular day, thirty-two workmen had to pass. All the men felt more or less the influence of the electrical currents. On the following morning twelve of these men presented themselves for medical advice, as they were all suffering from "electrical ophthalmia." They had been awakened during the night by severe pains in the eyes, when they found their eyelids so swollen that they could hardly open them. There were photophobia and running at the eyes. On examination the conjunctiva was found to be red and swollen. In eleven of these men the cornea was intact, but in the twelfth it was slightly affected. The pupil of the eye was in each instance normal and reacted normally. The fundus oculi presented nothing abnormal, except that in two or three of the men the veins were slightly turgid and the papillæ congested. The acuteness of vision and colour perception were in no way affected.

In a large works at Lamotte Breuil, on the River Oise, in which chloride of calcium is manufactured by the electrolysis of chloride of sodium and potassium, several of the workmen have suffered from an irritating form of skin eruption, characterised by a succession of crops of acne pustules and inflammatory nodules on the face, chest, and back of the trunk. The acne spots present a dark appearance, as if they contained grains of gunpowder. The colour persists long after the spots have disappeared. Dr. Fumouze, who has described the malady, calls it "Dermatose chlorique électrolytique," and states that this form of dermatitis has been met with in Germany in men similarly employed. The explanation of the cause of the malady which has been advanced by M. Jarackzewski[1] is the presence of certain substances deposited on the electrodes, among which are found one possessing strong oxidising energy, viz., chloranile or the tetrachloride of quinone, the vapours emitted from which are extremely irritating. The chlorine vapour that is given off produces irritation of the skin, but there is

[1] *Revue Scientifique*, quoted September 29, 1906.

apparently some other cause in operation, since it is the men who are engaged in the removal of the products of decomposition that suffer most. The means recommended to overcome the dangers are the immediate removal of the decomposition products from the electrolytic chambers after breaking up of the same in order to set free certain parts of the machinery once it has become cooled; wearing of gloves during handling of the products, frequent washing of the hands, a bath and douching before leaving work at the end of the day. Since putting into force these recommendations the malady has ceased to exist.

Dr. Alfred C. Jordan,[1] medical radiographer of Guy's Hospital, has drawn attention to sterility among X-ray workers. It is now admitted that azoospermia is produced by exposure to X-rays. If a worker has not taken every reasonable care to avoid exposing himself unduly to their action, he becomes sterile after working daily for a year or so. The wearing of specially prepared protective aprons is recommended. The back of the hands of an X-ray worker whom I have examined are swollen, tender, and cracked. So, too, are the finger-nails. He gets relief by rubbing them with vaseline. Other serious effects have followed exposure to X-rays. One of Edison's experimenters,[2] named Dally, after suffering for six months from scattered patches of a painless erythematous redness of the skin like scalds, noticed that his hands were swollen. Although thus affected he continued to set X-ray machines in hospitals and colleges for two years, when the burns began to smart and to tingle and to be extremely painful. His sufferings were so intense at night that he was obliged to lie with his arms in iced water in order to get sleep. Later on the left wrist became cancerous, and as the disease made rapid progress the left arm was amputated below the shoulder. Three months afterwards the little finger of the right hand became cancerous and had to be removed. Subsequently the right wrist was similarly attacked, and the arm had to be amputated below the elbow. The respite

[1] *British Medical Journal*, July 6, 1907, p. 15.
[2] "Thomas Alva Edison," by F. A. Jones, p. 248.

was of brief duration, for within a very few months Dally succumbed to the disease, which had become general. Although a martyr to a malady for which no cure was found, Dally's mysterious disease and regrettable death drew attention to the dangers of X-rays and to the absolute necessity of having the skin adequately protected.

According to Dr. Alfred Haas, of Munich, a similar danger is said to exist among the Röntgen tube makers in Germany. In testing the tubes upon themselves the men have suffered from a severe form of dermatitis of the hands—the usual effects being an acute inflammation of the skin followed by an eruption, at first vesicular and subsequently pustular, which frequently ended in ulceration not amenable to treatment, or in gangrene. The Röntgen tube makers no longer test the instruments upon themselves, but use the hand of a human skeleton which is encompassed with gelatinous material to resemble the hand of a living person. As in England, atrophy of the testicles has also been found to be one of the results of exposure to the electric rays. Of sixteen workmen who were the victims of azoospermia (Brown and Osgood: *Archives of Röntgen Rays*, 1905), all had been the fathers of families until they worked in Röntgen rays, after which the wives of all the men became sterile. The sterility continued for two years after the men gave up the work. In Germany the workmen protect their hands, face, and front of the body by large sheets of metallic lead. For the dermatitis alkaline lotions, oxide of zinc, and salicylic ointments have been found useful.

CHAPTER XIII

DISEASES THE CONSEQUENCE OF FATIGUE; OCCUPATION NEUROSES

THE stress and hurry of modern life are developing effects peculiar to the age in which we live. While labour-saving machinery continues to increase there is yet a degree of physical strain and nerve-tension being experienced by the workers the influence of which cannot be ignored. The lightening of the burden of the textile worker by improved machinery has not altogether made mill-work easier, for by raising the speed and increasing the output a larger amount of machinery has to be tended, and this constant vigilance imposes a considerable strain upon the worker. If this is true of simple muscular movements necessitating only mechanical supervision, how much greater must be the strain and exhaustion upon persons who in their employment are obliged to execute a series of educated and rapid muscular movements in which volition is sustained throughout.

Engine-drivers and Signalmen

are, as a class, healthy men. They are all medically examined before given work under a railway company. The occupation of engine-driving is consistent with long life. Engine-drivers who have fixed passenger trains to look after have regular hours. It is the men who are called upon at all hours to perform irregular work that suffer from the demands made upon their sleep and the opportunities of getting food and of eating it. Among this class dyspepsia is frequent; for the food that is carried away from home ceases to be

attractive, and as it is occasionally far into the night before the men return it is often impossible for them to get a good meal. Diabetes prevails among engine-drivers to a considerable extent. It is double that of the standard. Many of them die from this disease between 50 and 55 years of age. The malady is largely the result of the long-continued nerve-tension to which the drivers are exposed Acute pulmonary complaints, too, are not uncommon. Pneumonia is more frequently met with than phthisis. The mortality from accidents is lower than in any employés in the running department. An engine-driver who has once been in a collision, and whether the accident was his fault or not, is subsequently transferred to the mineral traffic department of the railway company, a change of work which, while it may be meant as a solace to public opinion, is acutely felt as a degradation by the person concerned. Whether it is as the result of the shock, or in consequence of their altered position in the railway service, engine-men under these circumstances become nervous and never quite regain the self-confidence they possessed before the accident.

What is true of engine-drivers is, in the main, true of signalmen. Many railway accidents are the result of the too long hours and the continued strain upon the nervous system of the men. They are overtaken by a kind of fear which paralyses them, or there is temporarily produced a degree of mental aberration. The chief causes of death among signalmen are diseases of the circulatory system and phthisis.

In a Parliamentary paper, "Instances in which Eight-hour and Ten-hour Signalmen were on Duty on the Railways of the United Kingdom for more than their Booked Hours during the Month of February, 1906," it is stated that the total number of instances shown in the return of one railway company alone was 617. In 430 of these instances the late working was due to the absence, through illness or other causes, of the men by whom the work should have been taken over at the end of ten hours, and the impossibility of obtaining relief owing to the short notice. In 162 instances the

overtime was worked, chiefly on Saturday night, to pass a late train. The total number of instances in the United Kingdom of eight-hour signalmen being on duty for more than their booked hours was 2,226, and of ten-hour signalmen being on duty for more than their booked hours the total was 9,512. These returns refer to the 9,164 signalmen who are eight-hour men, and 9,721 ten-hour signalmen in the United Kingdom.

It is unnecessary to dwell upon the strain necessarily felt by an engine-driver who is driving an express passenger train on a long journey. No sooner has he passed one signal than he is on the outlook for another, and as a consequence the nerve-tension is kept up all the time. It is not alone a question of observing signals, but also of attending to the rate of the running and its bearing upon the management of his engine. Furnished with a time-sheet on which is stated the second at which he ought to pass every station and every important signal-box, he is obliged to record on this sheet the actual time of passing. As a counter record is kept by the guard of the train and the signalmen, the work imposed upon the engine-driver is greater than most people imagine. There is nothing to indicate that the speed at which these men run their trains makes them careless of the dangers they have to avoid or heedless of the freight entrusted to them. On long-distance fast trains the fireman is also extremely hard worked. He is stoking nearly the whole way. Coal has to be shovelled into the firebox at the rate of two tons per hour. Seeing that there is imposed a severe strain upon the engine-driver and that the stoker is also fully employed, the question has frequently been asked, in view of the possible sudden illness of one or other of the two men, as to the advisability of having a third man on the engine. This is a question which railway experts alone can answer, but which in fairness to the public ought to be seriously considered.

Writers' Palsy: Scriveners' Spasm

One of the consequences of the oft-repeated use of the pen carried on for months and years is the development of a

peculiar spasm of the fingers, whereby, when a person is writing, the hand becomes unable to execute the commands of the will. Writing is an act learned by education: it never becomes automatic. Attention must be concentrated to a greater or less extent when writing. In scriveners' spasm the fingers during the act of writing become the seat of painful cramp, which makes it impossible for them to complete the word begun. Although in one sense the result of some defect in the function of the muscles and nerves concerned, it is more than probable that a central cause is in operation as well, and that there is fatigue of the brain as well as of the small muscles of the wrists and fingers. A long rest and abstinence from work may restore healthy function to the muscles of the hand, but even after a lengthened rest it is not uncommon for spasm unexpectedly to occur. This is a serious trouble to persons, such as clerks, who have to earn their living by copying, &c. There is not the least doubt that it is this circumstance and the long required rest, with the sense of impending poverty, that makes recovery so slow in the majority of these cases. When the spasm and the loss of power are well marked it is advisable to train the muscles of the other hand to execute the necessary movements, or for the individual to take up some other work, such as typing instead of writing. The possibility of writers' palsy occurring in those who have to use the pen for several hours every day raises the question incidentally as to whether it would not be well to encourage the study and practice of ambidexterity in our schools. By ambidexterity we might be able to obviate some such troubles as these just mentioned. Writers' palsy is certainly best got rid of by inducing other sets of fresh muscular movements. The intemperate use of alcohol and the excessive use of tobacco favour the development of fatigue neuroses and retard recovery.

Typists and Telegraph Clerks

are liable to similar troubles to those just described; so, too, are pianoforte players. *Mal télégraphique*, or telegraphists' spasm, was first described by Onimus, a Frenchman, in 1875.

Thirty years ago the malady was rare, but in the succeeding ten years many cases were recorded. It is met with mostly in those who use the Morse instrument. The Morse alphabet is composed of a series of dots and dashes, and the messages have to be quickly transmitted. Females do not appear to be more predisposed to the muscular spasms than males. Telegraphists who have suffered are prone to become depressed mentally. A long holiday should be insisted upon and ambidexterity encouraged.

Trap-Drummers' Neurosis

In the *Medical News*, February 7, 1903, Dr. Charles Aldrich, neurologist to the Cleveland General Hospital, Ohio, draws attention to a hitherto undescribed series of symptoms occurring in a man who had followed for twenty years the occupation of a trap-drummer. Besides being obliged to practise, he had to play twice a day in a theatre. The work was heavy and required great rapidity and strength. The drum had to be beaten by the operation of a pedal manipulated by the right foot. This gave him the use of both hands to play the other drums, triangle, and the various traps, hence the name of trap-drummer. His illness began with cramp-like pains and a feeling of exhaustion in the muscles of the right leg below the knee, and was accompanied by a sense of constriction of the leg as if the circulation had ceased. This was followed by burning pains in the knees when he began to walk or use the leg in beating. It required a pressure of 5 to 25 lbs. for each stroke to play the drum and a rapidity of movement equal to 150 to 180 strokes per minute. This always brought on a severe pain in the knee, and at the end of the performance the leg felt numb, heavy, and useless. On examining the right leg and foot which did the work, they were found to be better developed than the left leg and foot, but the muscles were thrown into a state of painful cramp when the movements required in beating the drum were made. It may be said of all occupation neuroses that the muscles which are liable to become affected by paralysis and painful cramps are those

which are called upon to perform almost continually movements that are the result of volition and sustained mental attention—movements, in a word, that cannot be relegated to automatic or excito-motor centres in the lower brain and spinal cord. Hence motion and sensation both become affected. It was only when Aldrich got the patient to educate himself to use the left instead of the right foot that progress towards recovery was effected.

It is astonishing how the exercise of certain muscles leads to hypertrophy of these muscles. In a Punch and Judy man who was an in-patient of the Royal Infirmary I found the muscles of the forearms and hands, but especially those of the thumbs, enormously developed and extremely strong compared with those of the other parts of the body. He told me that on several occasions on a Saturday evening, when some man in the crowd had interposed his arm between the dolls, he would bring down the wooden bâton in Punch's hands with such force as almost to break the arm of the intruder. The muscles of the thumbs and forearm had become overgrown through use. It is well to remember that over-employment can even affect hypertrophied muscles, as illustrated by the painful affection known as "hammermen's spasm."

It is unnecessary to multiply examples of fatigue neuroses. Violinists suffer equally with pianoforte players. Seamstresses are similarly affected in their hands, so too are type-setters. The cowherds in the Tyrol are said to suffer from milkers' spasm. All persons following occupations in which quickly repeated muscular movements with concentrated mental attention are required are liable to the painful cramps mentioned above.

School Teaching

The demand for education has created opportunities for an increasing number of young girls to take up teaching as a profession. To many girls the strain of preparation for becoming pupil teachers is too great; they break down entirely in their nervous system, while in the case of others

the confinement in school is a cause of anæmia, and the inability to sit and obtain rest during the menstrual periods is productive of pain and uterine displacements. Apart from these, the vocation of the female teacher is not unhealthy, so long as the schools are well ventilated and are not overcrowded. When the air is close and the classrooms too full, headache is experienced by many of the teachers. As pulmonary phthisis occurs in school teachers with greater frequency than in members of the other learned professions there is not the least doubt that the malady is caught in the school or the conditions of school life are such as to reduce the vital resistance of the individual and render him more liable to disease. As tuberculosis is an infective disease, and frequently the result of inhaling dust to which the specific bacilli are adherent, this raises the question as to the best means of ventilating schools and of laying the dust of schoolroom floors. The sweeping of floors should never be done in the morning before school hours—always after, and before being swept they ought to be sprinkled with some such antiseptic liquid as a solution of carbolic acid. Children who are known to be the subjects of tuberculous lung disease ought not to be allowed to attend the ordinary schools, nor should the attendance of children with open tuberculous sores be encouraged unless the wounds have been dressed antiseptically.

As a consequence of giving lessons in singing over a long period young school teachers occasionally become hoarse. On examining the larynx minute nodules, smaller than grains of semolina, may be observed on the vocal cords. Under complete rest to the voice, speaking only when necessary and then not louder than a whisper, recovery usually takes place. School teachers would act wisely if they did not use *dry* cloths to remove the chalk markings on the black-board, since inhalation of the fine dust in many instances is followed by irritation of the lining membrane of the throat.

Young school teachers who have not had the ordinary infectious ailments of childhood run the risk of catching these during epidemics in schools.

Domestic Servants

Domestic servants as a class supply a large contingent of patients to infirmaries. The "general" servant has often a hard life of it, owing to long hours, insufficient and improper food, and the want of proper sleeping accommodation. A large number of domestic servants become anæmic. Many of them suffer from dyspepsia and ulceration of the stomach. In a few the ulceration is followed by vomiting of blood and sudden perforation of the wall of the stomach. As a consequence of being too many hours on their feet some of the older servants suffer from varicose veins of the legs, while owing to confinement indoors headache and constipation are frequent complaints among all who are predisposed to anæmia.

CHAPTER XIV

DISEASES IN MISCELLANEOUS TRADES AND OCCUPATIONS

Tea Tasting

MEN employed as buyers and sellers in the wholesale tea trade, and who are therefore required to taste several samples of infused tea daily, frequently suffer from dyspepsia and insomnia. The infused beverage is seldom swallowed, the mouth is simply rinsed with the liquid; but as this is repeated several times in one day tea tasters frequently suffer in consequence from uneasy sensations in the stomach after food, flatulence, loss of appetite, and constipation. Their nervous system, too, becomes unstrung. Tea samplers suffer from nervousness and irritability, also from loss of sleep. In some instances there is emaciation and discoloration of the nails. The effects of tea tasting and immoderate tea drinking differ from those of alcohol in so far as the symptoms are mostly functional. If the intemperate use of alcohol is carried on for a long time, structural changes are set up in the liver, kidneys, and nervous system, which may lead to death even after indulgence in alcohol has ceased, but there are no similar organic changes induced in the internal organs as the result of the excessive use of tea. A patient has only to give up taking tea, when he begins to improve and his symptoms to disappear. When therefore tea tasters begin to suffer in the manner already mentioned, they ought at once to renounce the practice for a few months. There is an idiosyncrasy to tea. Some persons can follow the occupation of tea tasting without experiencing any ill effects. Those who cannot do so ought to renounce this particular part of their duty.

Fish Curing: Herring Salting

Allusion is made elsewhere in these pages to the risks to life and the dangers incurred by fishermen when plying their calling. Out in all sorts of weather and exposed to sudden squalls, their occupation is attended by considerable risk. It is of the curing of fish that I would speak, and especially of herring. This is an important industry. According to the Report of the Scotch Fishery Board, 90,000 Scots are employed in the various branches of sea fishing, of whom one-fourth are women, and these follow the occupation of fish curing. The perishable nature of the product and the unexpected appearance of shoals of herring at certain places render the trade peculiarly uncertain, and oblige employers to proceed at once with the cleaning and curing of large hauls of herring. As the herring migrate round the coast of Scotland and down the East Coast of England, the fish are followed by a fleet of boats and an army of male coopers and female curers, and as the migration occurs during the summer months, when in Scotland the days are long, the work is frequently carried on well into midnight. In the months of May and June the herrings are found at Stornoway and Thurso, but by July the fish have moved onwards to the Shetlands, Wick, Fraserburgh, and Peterhead, and for a time these are the centres of the herring industry. Later on in the autumn the move is southwards, to the Yorkshire and Lincolnshire coasts, so that by October, Lowestoft and Yarmouth are the principal seats of the industry. During the summer months, when the weather is dry and fine, little can be said against the surroundings of certain places where the work is carried on. The hours are long and the work is necessarily attended by a considerable amount of physical fatigue. For the best accounts of the herring industry we must turn to the Reports of the Lady Inspectors of Factories which are published in the Annual Reports of the Chief Inspectors of Factories and Workshops. The importance of the herring harvest is not realised until a visit is made into the far north of Scotland, when it becomes at once apparent how the industry affects the wellbeing of thousands of

people. The uncertainty of the supply of herring and the absence of local labour create special difficulties. Employers are obliged to import large numbers of workers, since it is impossible "to foretell with any degree of accuracy the places where or the exact times at which herring are most likely to be taken in great numbers; consequently the curer has to be prepared for dealing with a rich harvest, while fully aware that it may not await him." Although the commercial risks are considerable, they are on the whole favourable to the employer. It pays him to engage and pay retaining fees to a large number of women ready to deal immediately with heavy catches of herring, for when the boats come into harbour they are at once emptied of the fish, and the process of curing is begun and continued to the finish without any break in the work. The women who cure the herring are strong and healthy: they are drawn from the Shetlands and the Western Isles of Scotland, from the Highlands and Aberdeenshire, and while there is a considerable amount of friendliness among them, there is little intermingling of the workers. Each set adheres to itself, and particularly is this the case in regard to the hut accommodation provided.

After having wrapped bandages round the fingers that are most likely to be injured by the knives, the female gutters, having donned high boots, waterproof skirts, and a thick coat, proceed to the work of cleaning and salting. Two gutters and one packer constitute a "crew." Among the crews there is a considerable amount of rivalry, and as the gutting and packing of fresh herring come under the exception of unlimited hours permitted by the Factory Act, the physical powers of the crews who are competing with each other may become exhausted. The boats, too, come in at irregular hours; consequently just as much of the work may have to be done between night and morning as during the day. By working late on Saturday evening and commencing again at midnight on Sunday the workers usually succeed in getting the Sunday's rest. It is the irregular nature of the work and the long hours that try the health of the gutters. Occasionally they have nothing to do for days; at other times there is no possibility of getting leisure. Add to the long

hours the insanitary conditions of the surroundings, the wet ground on which the women are standing exposed to inclement weather, shortage of sleeping accommodation, difficulty of obtaining proper food and time to eat it, and it is small wonder that, strong and healthy as the women are at the commencement of the fishing season, they are towards the end of it frequently crippled in health. Some idea of the imperfect housing accommodation may be learned from the fact that in some places the sheds used in winter as stores are utilised as sleeping-rooms in summer, one bed being provided for each crew. As a consequence of the arduous work, long hours, exposure to weather, and the lack of healthy sleeping accommodation the vital resistance of the women is reduced, so that many of them on reaching home are found to be suffering from pulmonary disease or become subsequently the subjects of chronic rheumatism.

There are risks incurred from the use of the knife in gutting the herring, also from the stings inflicted by the jelly-fish which often adhere by their tentacles to the fish. Although the fingers which are liable to be injured are usually protected by bandages, yet wounds are often accidentally self-inflicted. Owing to the nature of the work and the difficulty of keeping the wounds clean the broken skin is apt to fester and the cuts to heal slowly, conditions which expose the women to the possibility of blood-poisoning. These are risks to which the gutters as a body are exposed, yet fortunately few of the women become ill from this cause. In addition to the overcrowding and insufficient hut accommodation the women complain of the deficiency of sanitary conveniences. There is not the privacy for the women that there ought to be, either at the curing stations or near their huts, nor is there always an adequate supply of pure water for drinking purposes and washing. As the industry is a profitable one, employers should be obliged to pay more attention to the requirements of female workers and should be compelled to provide proper sleeping accommodation and easily accessible sanitary conveniences, and, whenever possible, not to extend the hours of work beyond the limits of a reasonable working day. The evil effects of the work

are not always in evidence during the busy season; it is later on when the women, having returned to their homes, exhibit the signs of physical fatigue and of disease which may be permanent. Were it not for the fact that the women are strong and healthy at the commencement of the season and are generally above 20 years of age, there would be a greater amount of ill-health to record.

Younger girls, *e.g.*, under 18 years of age, are employed in the curing and smoking of haddocks, also in the preserving and tinning of fish, but these girls live at home owing to the industry being purely local. The surroundings in which the work is carried on are not always good. The hours, too, are long and are particularly trying to growing girls. If the hours of work were better regulated, the curing and smoking of fish would become a healthier occupation.

Fruit Preserving

The cheapness of sugar and the increasing inexperience and helplessness of many of the wives of the working classes as regards cooking in all its branches, are creating a growing demand for factory-made jams. The art of preserving fruits, of making sweet cakes, and of baking is declining as a domestic pursuit in most parts of the country. To meet this attempts are being made by municipal and other authorities to instruct the rising generation in cookery. Ignorance of cooking on the part of the wives and daughters of the artisan and poorer working classes is responsible for much of the domestic discomfort, also for the poor physique of some of the children of to-day, and the wasteful extravagance in many a home.

Many of the places in which jam is made in this country ought not to be allowed to exist. Some manufacturers are of the opinion that any building is good enough for their trade. Consequently we find jam factories in courtyards contiguous to stables and even more objectionable buildings and with no attempt made to provide good flooring or satisfactory ventilation. On the other hand, several of the jam, chocolate, and confectionery factories which I have

visited at home and abroad are models of cleanliness. There is no reason why all jam factories should not be such, for if the British public only saw some of the places and knew how preserves were made it is questionable whether the taste for bought jams would be as widespread as it is. Fortunately the old type of factory is disappearing.

There is neither any difficulty to be overcome nor any intricacy of process to be observed in the making of preserves. Much of the work can be done by unskilled labour. Machinery is in use for the removal of the stones from stone fruit. What are essential in a jam factory are cleanliness and attention to minute details. The work is not light, and yet many employers hesitate to introduce labour-saving machinery. By young persons weights have to be carried that are beyond their strength, and owing to the slippery state of the floors falls are frequent. Burns and scalds from the boiling mixtures are not unknown. There is a relaxation of the Factory Act which allows of overtime being worked during some of the summer months, and in consequence of this there is a tendency for employers to overwork the younger hands especially. To some extent this might be prevented by the fruit being cleaned before it is sent to the factories, and with the ready means of conveying information by telegram between the growers of fruit and the preserve manufacturers, there need not be the sudden and unexpected arrival of large quantities of perishable fruit towards the close of a working day, which, if it is to be boiled at once, will necessitate overtime.

With judicious supervision the excessive moisture in the boiling-rooms can be restrained, and considerable discomfort and injury to health thereby prevented. The removal of excessive steam is desirable owing to its chilling effects upon the workers, many of whom are thinly clad, are anæmic, and of poor physique. In the large towns the girls are not always drawn from the best classes of workwomen. They are ill-shod as well as badly clad, and as they have to stand for hours on wet floors, chilling of the extremities and the long shifts lead to functional and structural derangement of the pelvic organs, and lay the basis of female disorders and displace-

ments. During the spurt in the trade in the summer months the work is fatiguing; it is practically continuous, there being little time for rest and meals. These conditions Home Office Regulations have already materially improved. The evil effects of working long hours in jam factories may not show themselves in female workers until after long service therein, or after the women have given up the factory altogether.

Label Licking

Formerly much in vogue in thread mills and in industries connected with the sale of small packets, label licking fortunately is falling into disrepute. On the occasion of my visit to several factories wherein the practice was carried on it was not uncommon to see young girls sticking labels on bobbins after having licked them. In many instances the effect of this practice was the development of enlarged glands in the neck and small sores on the tongue. The coloured labels often contain copper and lead, and had it not been for the varnish on the labels being of some resistance, there might have occurred metallic poisoning as well. Apart from this risk, the adhesive agent on the labels is occasionally obtained from unhealthy sources. While the gum may be normal, the water made use of to dissolve it may not be pure. Besides it is not gum but a substance of an animal nature, a serum, that is sometimes employed. To the use of this serum and gum must be attributed the malady known as "stamp-licker's tongue," in which small ulcers are found on the tongue and inside of mouth. From these ulcers septic material may be conveyed to the submaxillary glands in the neck, and induce in these and adjacent glands an acutely painful inflammation. Although the ulcers in the mouth are readily cured by antiseptic washes and constitutional treatment, label licking is a nasty practice which ought to be prohibited, not simply on account of the risk of septic affection, but of the great sacrifice of saliva it entails upon young girls at an age when they require the secretion for digestive purposes. The quantity of saliva lost to the system may be gauged by the fact that half-timers will lick as many as forty to fifty

gross of labels in one day, and an adult woman ninety gross. Mechanical contrivances exist for putting on labels.

In the thread mills of Scotland special power-driven machines are in use for labelling reels of thread. It is a matter of regret that in several of the large mills in England manufacturers seem unwilling to put an end to the insanitary method of effecting the labelling by means of the tongue and saliva of girls. Miss Squire, H.M. Inspector of Factories, recently found in one factory forty little girls, twenty-one of whom were half-timers, employed in labelling reels of sewing silk and skeins and balls of embroidery silks. All of them were moistening the adhesive labels by the mouth, sometimes to the number of thirty gross a day or more. The tongue of each girl had the polished tip characteristic of label licking, while the remainder of the tongue was brown from the gum. Some of the girls complained of the gum tasting nasty and of making them feel sick at times, others complained of feeling thirsty. One woman had sores on her lips, which, while possibly a consequence of the work, presented a breach of surface through which infection might enter. Employers occasionally complain that where dampers have been provided the employées refuse to make use of them. In Leek, Staffordshire, a centre of the silk thread industry, there are 250 women and girls who earn their living by licking labels. The girls, who are paid on piece, can get through 30 to 40 per cent. more labels than those who use the dampers. This circumstance explains why dampers are not used. The work is badly paid. Few girls make more than 2s. to 2s. 6d. a week.

Sugar Refining

The manufacture of beetroot sugar is less a British than a continental industry. In sugar factories the men who are employed to stir the molasses, also those who work at the refining processes, occasionally suffer from skin eruptions which prevent them following their occupation. There is an affection known as the "lymphangitis of sugar makers," but this inflammation of the lymphatic vessels is not a serious

matter. At the outset the lymphangitis is attended by slight fever and loss of appetite. If the workman continues to follow his employment, there may occur a crop of boils, the skin around which is hard and indurated. Occasionally the boils suppurate. Within a fortnight the workman is able to return to the factory. It is interesting in connection with this to remember that patients who are the subjects of diabetes and who are passing sugar in their urine also suffer from boils. In the case of sugar makers it is more than probable that the micro-organisms of the air and water settle down upon the fine hairs of the skin, and through the follicles gain an entrance into the skin itself. The sugar itself seems to exercise some local influence, for it may act upon the blood, and thus, as in diabetes, predispose to the formation of boils, eczema, and ulceration of the skin. A series of experiments carried out by M. Gaillot[1] at Aisne has shown that the lymphangitis of sugar makers is caused by an organism, the *Staphylococcus pyogenes aureus*, and that this micro-organism is not found in freshly-made molasses, but is met with in the residue, and that the temperature of the factory and the condition of the skin of the workpeople are both favourable to the development of the microbe. During the multiplication and growth of the *Staphylococcus pyogenes aureus* the micro-organisms produce fatty acids by transforming saccharine material into lactic, acetic, and butyric acids, while virulent toxins are formed as well. These soluble poisons along with the micro-organisms may penetrate the skin by the hair-follicles.

The treatment of the skin affection consists in bathing the skin with such antiseptic and germicidal solutions as mercury perchloride or carbolic acid. In the newer processes of sugar manufacture in which mechanical methods have supplanted hand labour boils are not so frequently met with among the workmen.

Manufacture of Aerated Waters

The manufacture of aerated waters is a dangerous industry, for owing to the pressure under which the bottles are filled accidents arise through breakage. The bottles when they fly

[1] *Bulletin de l'Inspection du Travail*, 1903, Nos. 3 and 4, p. 197.

produce serious wounds, for these are usually deep and blood-vessels are frequently severed. Until recently the loss of an eye was not an uncommon occurrence in aerated mineral water works. Since the introduction of face-guards and gauntlets the number of accidents has been materially reduced. Bottlers, wirers, sighters, and labellers are all alike liable to be injured unless protectors are worn. The bottlers are most exposed to danger. The bottles often burst in the machine with considerable force and fly great distances, occasionally inflicting serious injury upon workpeople several feet away. Bottling is done both by men and young women. Wiring has gone out greatly since the introduction of patent stoppers. Sighters examine the filled bottles by holding them up to the light to see if any specks are present. Sighters and labellers often discard the protective wire gauze face-guards and gauntlets. The sighters say the face-guard interferes with their proper observation of the bottles, and the labellers dislike the gauntlets, or woollen mittens, because they interfere with the rapid handling of the bottles. If the face-guards are made of light wire and do not press too closely upon the face, but fit comfortably, there is less objection raised to them, but if they are at all heavy or of a clumsy make the workpeople refuse to wear them. All persons employed in an aerated water works are exposed to the risk of bottles bursting and flying through the workroom. The other dangers incidental to the trade are standing in the wet and working in wet clothes. In addition to wearing the protectors above mentioned, splashboards should be provided, also waterproof clothing and clogs for the feet.

Glass Making

Glass is made from fine sand that has been carefully dried, and is known to be free from iron. The sand supplies the necessary silicic acid. To it soda, salt, lime, felspar or quartz, and according to the colour wanted, red lead, black oxide of manganese, nickel, arsenic, or copper are added. Boric acid may be substituted for silicic acid. The substances when mixed are melted in a circular furnace at an

extremely high temperature. Through small openings in the wall of the furnace workmen wearing blue-tinted spectacles can watch the molten mass. At a high temperature the vitreous material is in a fluid state, and can be poured, moulded, or blown. Blowing is usually adopted for hollow glassware. The principal instrument of the glass-blower is a hollow iron tube, one end of which is dipped into the lake of molten material in the furnace. On removing the iron tube there is a blob at the end of it. In blowing down the tube the glowing mass at the distal end assumes a globular shape. This can be blown into the particular form required.

Glass-blowing is, comparatively speaking, an unskilled trade, and one of rather low standing. It throws a good deal of strain upon the muscles of the trunk, also upon the lungs, which in course of time may become emphysematous and the seat of bronchitis. This, however, as we shall see later on, has been doubted. The excessive heat and perspiration create a sense of thirst not always easily appeased.

Sheet and plate glass are obtained by pouring on to an flat iron table the molten mass from the furnace or crucible and rolling it to the required thickness. Beyond burns and the effects of exposure to the great heat the work is not dangerous, nor is there anything unhealthy in the polishing of glass on the oscillating tables so long as simple polishing powders are used for the purpose. Glass polishing has been a source of ill-health to persons employed, but that has always been when the polishing powder has contained lead.

Engraving on glass is generally performed by exposing glass to small wheels covered with leather and revolving rapidly or by the application of hydrofluoric acid. This acid has the power of eating out, as it were, the glass wherever applied. The portions of glass not to be acted upon are protected by a coating of wax. The whole of the glass is in the first instance covered with wax, and by means of a hard pencil the emblems are delineated upon it. Hydrofluoric acid is a poison, and when applied to the skin it may cause ulceration which is both painful and slow to heal. The vapour given off by the acid causes running at the eyes and nose.

Glass makers suffer at times from the effects of the great heat and exposure to rapid variations of temperature. Bronchitis and pulmonary diseases are common among them. In the *Münch. Med. Wochensch.*, 1904, Prettin and Liebkind discuss the subject of the pulmonary emphysema of glass-blowers. Physicians who attribute emphysema of the lungs to mechanical causes generally allude to instances of the disease in men whose occupations require powerful respiratory efforts frequently repeated, *e.g.*, players on wind instruments, glass-blowers, &c., but Fischer did not find one single case of pulmonary emphysema in five hundred army musicians whom he examined. My friend and teacher the late Sir Wm. Tennant Gairdner, in his lectures on the causation of pulmonary emphysema, used to tell his class of the absence of emphysema of the lungs in well-known bagpipe players. Prettin and Liebkind examined 230 glass-blowers, of whom 218 were from 25 to 50 years of age, also 12 glass-blowers aged from 50 to 62. All had worked at the trade for more than twenty years. The numbers were 101 for more than thirty-one years, and 24 for ten years. Of these 230 workmen there were only 5 who were suffering from pulmonary emphysema. One hundred and sixty-four of the men aged less than 40 years did not furnish one single case: of 54 men from 40 to 50 years of age only 2 were attacked, and of 12 more than 50 years of age 3 presented physical signs and symptoms of emphysema. Using pneumatomatic methods, these observers found that the intra-thoracic pressure in all glass-blowers is greatly increased. Notwithstanding this fact they maintain that glass-blowing does not produce pulmonary emphysema, and that when it does occur discrimination should be made between the distension of the alveoli of the lungs caused by repeated respiratory efforts and the same condition induced by inhalation of dust and the frequent colds and bronchitis to which glass-blowers are subject. Cough alone, according to Prettin and Liebkind, is not of itself causative of emphysema of the lungs. Although according to their statistics emphysema in glass-blowers is uncommon, their inquiry showed on the other hand that pulmonary tuberculosis is met with in glass-blowers to the extent

of 20 per cent., part of which they attribute to the unhealthy condition of the trade and to direct contagion by the blow-pipe which is in use being passed on from one workman to another.

As there is usually a great amount of dust being blown about in the neighbourhood of the furnaces the eyes of the workmen occasionally become inflamed. Glass-blowers should have and should use their own blow-pipes and not take them up indiscriminately, owing to the possibility of tubercular and syphilitic infection. The men who use the blow-pipes are liable to "glass-blowers' mouth," a condition to which Dr. Schule, of Berlin, drew attention, and in which large swellings like air-cushions appear on the cheeks, extending from the angle of the mouth to below the ears. The swellings look like mumps, and involve the parotid gland. They crepitate under the finger, and by pressure can be made to disappear. This relaxation of the cheeks is by some writers attributed to faulty blowing. I have met with this facial deformity in glass-blowers in Newcastle, but it is not of common occurrence in the North of England. Dr. Schule found it present in 25 per cent. of the men employed. The deformity is due to air under high pressure entering the duct of the parotid gland, where it opens into the mouth inside the cheek, and where thick pale patches of hardened mucous membrane can be seen—*plaques opalines*—which Guinard regards as the result of the great straining and pressure the buccal mucous membrane is exposed to during the act of blowing. In the course of one day a good workman will blow as many as six or seven hundred bottles. This is an indication of the strain the men are exposed to, and from which, in addition to the deformity just mentioned, the men suffer from deafness consequent upon the increased internal pressure in the middle ear. Many of the men, owing to the peculiar manner in which they grasp the iron blow-pipe, suffer from a deformity of the fingers known as *main en crochet*. In the new methods of glass-blowing the blowing is not done by men but by machinery. Compressed air is driven into the glass by machinery, so that instead of a man being able to throw off only 40 glass tumblers in an hour, 1 machine worked

by 4 men and 7 boys can by the new method throw off 500 in an hour or 5,000 in a working day. The substitution of compressed air will do much to remove many of the minor ailments glass-blowers have suffered from. It is also more cleanly and hygienic.

There is one other malady glass workers are subject to and to which attention must be drawn, and that is the risk to the men of losing their eyesight from cataract. The statistics of ophthalmic surgeons in regard to the frequency of cataract in glass workers are somewhat at variance, but from figures supplied by the Yorkshire Bottle Trades' Union it appears that out of 114 cases of men on their superannuation fund 37 went on the fund on account of cataract.[1] It is believed that the crystalline lens of the eye in glass workers becomes more frequently opaque than in men following other occupations. Dr. Probsting, an oculist in Cologne, found cataract present in 12 per cent. of the factory operatives in Ehrenfeld above 40 years of age, and Meyhöfer in 11·6 per cent. of 506 glass workers. In Sunderland there are 400 men employed in glass factories. Dr. Wm. Robinson, of that town, informs me that 48 of these men have been operated upon for cataract. It is the furnacemen, or those who are exposed to the great heat and light, who suffer most. Bottle-makers have to look into large tanks filled with molten material, the temperature of which is often 2,500° F. Robinson finds that the cataract commences in the posterior pole of the lens, and Hirsch is also of the opinion that it begins in the cortical layer on the posterior wall of the crystalline lens. According to Cramer[2] it is the left eye that is the more frequently affected. The workman usually stands with his left side to the furnace, the left hand supporting the blow-tube, which is held and directed by the right. The change in the lens proceeds so slowly that it is not until months or years have elapsed that the men consult

[1] Through the kindness of Mr. Alfred Greenwood, Secretary of the Glass Bottle Makers of Yorkshire United Trade Protection Society, I am able to state that since these figures were published other 85 cases have been added to the superannuation fund, making a total of 199, and of these 85 cases 15 were placed on the fund on account of cataract.

[2] *Klin. Monatsblätter f. Augenheilk.*, January, 1907.

a doctor. Meyhöfer attributes the physical and structural changes in the lens to excessive perspiration, or, in other words, to great loss of liquid from the system, as in the cataract of diabetic patients; but it is much more likely that it is the result of the extreme heat and the brilliant white light, which has a dazzling effect, and which by fatiguing the retina of the eye reflexly influences the nutrition of the lens. Cramer attributes the cataract to the chemical rays emitted by the glowing glass and due to the calcium present in the sand. The wearing of blue-tinted spectacles by the men when at work would go far to prevent this tendency to cataract in glass workers. The interposition of a flat glass dish between the chink in the furnace and the workman, and filled with a red solution of such concentration as not to impede the view, would cut off the chemical rays from the calcium salts just mentioned and would act as a preventive to cataract. Fortunately, when the worst comes to the worst nearly all the cases do well after operation for the removal of the opaque lens. Mr. Simeon Snell of Sheffield is of the opinion that the frequency of cataract in glass-blowers is overrated.

Brick Making

In an appeal almost as plaintive as that of Mrs. Barrett Browning in the "Cry of the Children," George Smith, of Coalville, laid bare the iniquities that existed and the hardships that were endured by children in the brickyards of England only a few years ago. "The matter of fact that I should wish to bulk out in all its largeness and shame before the philanthropy and Christianity of England is that in our brickfields and brick works there are from 20,000 to 30,000 children, from as low as 3 and 4 up to 16 and 17, undergoing a 'bondage' of toil and a horror of evil training that carries peril in it. . . . I claim the protection of the law for these children specially, and all children universally, by placing them within the inspection and regulation of an Act kindred with the Workshop or Factory Acts."[1] The

[1] "The Cry of the Children from the Brickyards of England," 1879.

condition of the children employed in the Midlands in brick and tile making in the seventies was deplorable. George Smith himself began life by assisting to make bricks at the age of seven, and he incidentally alludes to the harsh and unkind treatment often meted out to him. At the age of nine his occupation consisted in carrying upon his head loads of clay weighing 40 lbs. in weight from the clay heap to the table upon which the bricks were made. This went on, practically speaking, without intermission for thirteen hours a day. On one occasion after a customary day's work he was obliged to carry 1,200 nine-inch bricks from the maker to the floors upon which they were to harden. For all this labour he received sixpence. The fatigue induced brought on a serious illness. Smith's experience was only that of hundreds of other children. Boys and girls from nine to twelve years of age worked together in the brickyards in a state bordering upon nudity. Their employment consisted in carrying damp clay upon their head to the brick makers, or in carrying away the made bricks to the drying floors; and as the work went on for thirteen hours a day the children often travelled a distance of 20 miles, and yet the Government officials could not interfere, since the Acts of 1867 did not apply to establishments in which less than fifty persons were employed. It was impossible for such young children, many of them improperly fed and all of them poorly clad, to keep up with the requirements of the men at work, and so between curses and blows this iniquitous slavery went on for years. As a proof of the heavy weights carried by the children, Smith removed a piece of clay which a child of nine years of age was carrying and found that it weighed 43 lbs. This child covered daily a distance of 12½ miles, in one-half of which the weight had to be borne. In those days a workman made on an average 3,000 bricks a day, equal to 12 tons in weight, and these had to be carried by two children. Under these degrading conditions there is small wonder at the ignorance and immorality that prevailed and at the physical degeneration of the children. As the boys grew to manhood they rose to higher positions in the brick-

yard, but without any true knowledge of their duties, religious or social. Thriftless and ignorant, the years went by, and when these men became prematurely old the workhouse was their goal. Eighty per cent. of the males who applied to one of the large unions for relief were brick makers.

A Brickyard Act was passed in 1871 which did much to change the character, habits, and customs of those in the trade. Since then the children have been spared the long hours, and all of them can receive the benefits of a school education. They are no longer permitted to commence work in the summer months at 5 a.m. and go on until 8 and 9 p.m. Notwithstanding all that has been done in the way of factory legislation, cases still are brought into court of young persons being worked overtime and of being obliged to carry weights upon their heads far beyond their strength.

Brick making cannot be said to be an unhealthy occupation, except as regards exposure to the weather, the temperature, and fatigue. The bulk of the work is carried on in the open air. Ulcers and varicose veins in the legs are frequently found in the workers who knead the clay. The moulders suffer from painful and inflammatory swellings of the hands and wrists, and the palm of the hands may be the seat of a dermatitis.[1]

As a consequence of the hard work men become prematurely old. In the brickyards around Cologne the workpeople suffer from anæmia, due to the presence of a parasite in their intestinal canal (see "Ankylostomiasis"). In England brick makers live at home, but in certain parts

[1] The introduction of machinery is altering the manufacture of bricks. While these pages are passing through the press I have a young woman twenty years of age in my ward, in the Royal Victoria Infirmary, who is a brickmaker, and who, although a strong, healthy girl and free from organic disease, was admitted on account of sheer exhaustion. She was simply worn out. She informs me that she can make 20,000 bricks in one day, and that she is paid at the rate of twopence-halfpenny per 1,000 bricks. The lifting off of the bricks is tiring work. By working from 6 a.m. to 7 p.m. she has sometimes made as much as from 4s. to 4s. 6d. a day.

of the Continent the workpeople are housed in wooden barracks, most of the dormitories of which have no windows, the bedding swarms with vermin, and overcrowding prevails. Rather than occupy such places the Factory Inspector of Augsberg states that the workpeople sleep out of doors.

Coal-tar, Pitch, and Allied Products

Technical chemistry has demonstrated what a world of wealth and variety of colours are concealed in tar. In the distillation of tar certain oily liquids are obtained. From the lighter oils benzine is obtained and from the heavier daraffin. Carbolic acid is also a tar product. During the distillation of tar, such gases and products as ammonia, carbonic acid, sulphuric acid, sulphurous acid, and creasote are given off. Persons brought into contact with these products occasionally suffer from inflammation of the eyes, running at the nose, bronchial catarrh, dyspepsia, headache and vertigo. Frequently the skin becomes dirty looking and cyanosed. Men employed in pitch works suffer in a similar way from the vapours given off during the pouring and settling of the molten material. During the pounding or grinding of dry pitch large quantities of dust are given off. Many of the men who follow the employment not only become bronzed and sallow, but their skin becomes the seat of a peculiar cancroid eruption such as is occasionally met with on the scrotum of chimney-sweeps. In other persons there may be bronchitis, digestive disorders with dark stools, also ulceration of the nose.

The question as to whether manipulation of tar products or exposure to the fumes given off by coal-oil and tar is capable of giving rise to cancer has come before me in the case of three men employed in grease works. These men in following their employment all worked with their sleeves rolled up to above the elbow. It has been observed in the trade that when men have warts on their hands these frequently disappear when they first undertake the work, and, on the other hand, that in men whose skin has been quite healthy, wart-like growths are apt to develop when

they have followed their employment for some time. In addition to the warts, of which there may be as many as from thirty to forty on the hands and forearms, there develop hard nodules in the skin which ulcerate and often exhibit very little tendency to heal. The edges become hard, and the ulceration, extending to the deeper tissues, may ultimately involve the bone and necessitate, as in one of the men I have alluded to, amputation of the arm. The appearances presented by the ulcer are those of the type of cancer known as epithelioma. The presence of these warty growths on the forearms and hands, and of ulcers that tend to take on malignant characters, in tar and pitch workers is so frequent that they must be in some way or other associated with the employment. The morbid processes advance very slowly, and therefore do not readily unfit the individual for work. In many instances removal of the ulcer is not followed by any recurrence of the growth, but a return to the work lays the person open to fresh developments. On the forearms of one of the grease workers above-mentioned there are numerous small patches of induration, some of which have ulcerated and exhibit no tendency to heal. The edges of the ulcers are hard and brawny. There are, in addition, scattered all over the forearm numerous black warts of various sizes, also several scars of a pale colour compared with the bronzed skin that surrounds them. One of these men, aged fifty-eight, has worked among coal-oil and tar products for thirty years. The scars referred to are the remains of ulcers that have healed. In the case of his son, aged twenty-seven years, the ulceration took on the characters of malignant disease, and on that account the arm had to be amputated above the elbow. Although it is usual when the disease is treated by surgical operation for no recurrence of the growth to take place, in this particular instance the glands in the armpit and neck became subsequently enlarged owing to infective particles having reached these glands by the lymphatics, and the patient became the subject of secondary cancer. Microscopical examination of the ulcer leaves no doubt as to the cancerous nature of the lesion. Knowing that in the case of chimney-sweeps' cancer

arsenic is present in soot, and may possibly be a cause of epithelioma, I analysed the coal-oil these men had been manipulating, but failed to find any traces of the metal. The Departmental Committee on Compensation for Industrial Diseases has recommended that the malady should be made the subject of compensation.

Motor-car Driving: Motor Garage

In the *Lancet*, July 7, 1906, Mr. W. J. Burroughs reports the case of injury to the spine of a motor-bus driver who, on a particular day, had considerable difficulty in starting his engine. In turning the starting-handle and giving it a jerk considerable force was required. Owing to the muscular strain involved in this act he lost the power in his legs, and was for a time incapacitated for work. Motor-car drivers are exposed to all sorts of accidents, some of which are due to starting the cars, others to excessive speed, collisions, &c. I have recently had under my care a young chauffeur who, when trying to set his engine in motion, had one of his hands forcibly driven against the dial marker by the wheel revolving suddenly. His median nerve was ruptured, and in consequence of a bad union having taken place there was loss of sensation and loss of power in the hand, which were restored by surgical operation. In what is known as "chauffeurs' fracture" it is the radius that is broken. The injury is consequent upon the sudden backward jerk of the starting handle. Pain in the wrist is at once experienced, and crepitation can shortly afterwards be felt. In some of the cases there is no deformity—the physical signs are simply those of separation of the styloid process—but in others the deformity is considerable. The right hand, the one usually affected, is displaced in a dorsal and ulnar direction. The lower end of the radius may be found projecting immediately under the skin on the flexor surface of the wrist. Lucas-Championnière distinguishes two forms of chauffeurs' fracture: "one direct, and caused by the lower end of the forearm being struck by the reversed handle; the other indirect, and caused by a violent jerk while the wrist is hyper-extended (*fracture par arrachement*). . . . Occasionally the fracture seems to be

caused by the palm of the hand being violently struck (*compression fracture*)." [1] Madelung attributes the fracture to the fact that the hand is so forcibly bent backwards by the handle that the styloid process of the radius is torn off. The kind of fracture that ensues depends upon whether the chauffeur retains his grip on the handle or not.

Chauffeurs have consulted me for headache, loss of appetite, and giddiness on account of inhalation of the petrol vapour when cleaning the cars; others, in consequence of the strain upon their nervous system in frequently repeated long drives, have sought my advice owing to tremors and loss of confidence in themselves without any such concurrent cause as indiscretion in the use of alcoholic stimulants. Rest from driving for a few days, along with tonic medicines to which bromide of ammonia or potassium is added, gives satisfactory results and a speedy cure.

It is unnecessary to emphasise the necessity for wearing goggles, on account of insects in the air and the irritation to the eyes caused by dust.

Persons driving in a motor-car have been accidentally poisoned by carbon monoxide gas. In an ordinary way the carbon monoxide which is produced in the explosions escapes by a tube which discharges behind the car, and cannot therefore injure the occupants. A lady and her two daughters who had been driving in a closed motor-car became at the end of half an hour the subjects of tingling noises in the ears, vomiting, and unconsciousness. The car had recently been mended, and owing to loosening of the partitions of the floor the burnt gases had found their way into the interior of the car and had poisoned the inmates.

Laundries

The hardships experienced by laundresses who work at home, and who in a large city like London have to compete with the laundries owned by companies and run by machinery, are graphically told by Miss L. A. E. Deane, H.M. Inspector of Factories in "Dangerous Trades," to whom I am indebted for much that follows in the text. The social changes of our

[1] *Medical Review*, November, 1906, p. 591.

times, the increase of town populations, and a diminishing aptitude on the part of the rising generation for laundry work, are tending to the development of company laundries and public washhouses, and so far as towns are concerned there is not the least doubt that these laundries will increase. To have the washing done away from home is in some instances a necessity, in others it is a luxury. A new industry has thus sprung up in our midst. As time goes on it will give employment to an increasing number of hands drilled and organised so as to look after particular kinds of work. At present 100,000 persons are employed in laundries. In towns where the atmosphere is smoky bleaching can only be carried on by artificial means. Some of the bleaching powders used are injurious to the hands of the workers. They are a frequent cause of painful cracking of the skin and of eczema. Owing to the variety of the machinery in use accidents are not unknown. In certain processes the women are exposed to high temperatures, especially in the ironing department of large laundries where the washed linen is drawn under hot revolving rollers, and where a temperature of 90° F. even in winter has to be borne by the girls that feed the machinery. It is the use of machinery that has brought laundries within the sphere of the Factory Acts and enabled owners to employ comparatively unskilled labour such as can be obtained from girls of fourteen and sixteen years of age. As the public requirements increase there will be a greater demand for girls as machine tenders, for laundries run by machinery are fast displacing the hand laundries in which five or six women only are employed and the work in which is frequently carried on in, or close to, dwelling-houses. It is unnecessary to descant upon the inconvenience and discomforts of the washing day at home in small houses, or upon the unhealthy atmosphere created by the steam and heat and by the disagreeable odours that are raised in the processes.

The number of accidents in laundries is unusually large. In 1906 there were 301 accidents reported to the Chief Inspector of Factories—46 males and 255 females. The increased number of accidents affecting women and girls is probably the result of the growing use of ironing machinery

and of the employment of young, unskilled girls in operating and cleaning it. Miss Sadler, H.M. Inspector of Factories,[1] draws attention to the rapid increase in the number of mechanical calenders, ironers, wringers, and hydro-extractors used in laundries. A most unusual cause of death in laundry workers has been reported by Miss Tracey. Two persons are reported to have died of tetanus; one, a girl aged fifteen, got a splinter under her finger when washing the messroom floor of the laundry and died two days afterwards; the other was a man who received injuries while trying to start his engine. How the tetanus bacillus got into the laundry it is impossible to say. In each instance the fatal illness had nothing to do directly with the employment. Probably the flooring of the messroom had become infected by the soiled boots of the workers.

Apart from the unhealthy influence of the high temperature and steam, there has hitherto been the tendency for the employées to be worked too long and for the hours to be irregular. Long before the establishment of large laundries we as medical men were familiar with the varicose veins and ulcers on the legs of women who went from house to house doing a day's washing; and although in the modern laundry machinery has replaced hand labour, women are still obliged to be on their feet for many hours during the day and are thus still predisposed to these minor but troublesome ailments. Many of these women are so poor that when they become unfit for work they gravitate towards the Union Infirmaries. Among the patients in the Wandsworth Union Infirmary the proportion of laundresses suffering from ulcers of the legs is 1 in 6, whereas in non-laundresses it is 1 in 23; and in the Isleworth Infirmary 1 in 6 laundresses suffers from ulcers on the legs, while in non-laundresses the proportion is 1 in 25 to 31. There is a considerable amount of ill-health among laundresses, especially the younger women, since the work has to be done by them standing and in a high temperature, which cannot be other than exhausting. The hours per week of workers in laundries are longer than those of persons

[1] "Annual Report of the Chief Inspector of Factories and Workshops," 1906, p. 203.

employed in textile factories; 76 hours a week may be spent in laundries, not including meal hours.

In visiting large laundries I have been struck by the pale and anæmic look of many of the women employed in the department where ironing by hand is carried on. Many of the women suffer from headache and tender eyes consequent upon bending over the table and inhaling some of the coal-gas which escapes from the tube or jets and which is kept lit to maintain the temperature of the irons. Some of the symptoms are the result of high temperature and mild carbon monoxide poisoning.

There is a current opinion that women employed in laundries are intemperate, and that the conditions of the work are such as to lead them to drink. The close atmosphere, the wet floors, and the disagreeable odours in some of the departments are extremely trying; the hours are long and the work is exhausting; the chemicals used, such as soda and ammonia, by causing dryness of the throat create a thirst which the workers feel a draught of beer will allay. I was certainly astonished in visiting laundries in London to find that at certain hours of the day a stop was called and that cans of beer were brought into the laundry and sold to the workers. Is there any other industry in which twice a day the work of the factory ceases for ten minutes to allow of beer being drunk by the workers? When we remember that it is to women the beer is being distributed and that the female sex is more prone than the male to some of the more serious nervous affections caused by alcohol, *e.g.*, peripheral neuritis followed by paralysis, to say nothing of the particular relations of woman to offspring, no words can be used sufficiently strong to condemn a practice which, while it may allay immediate sensations, is in the long run productive of the most serious consequences not confined to the workers themselves. In many of the large ironworks in the North of England and in many of the factories wherein high temperatures are experienced the men drink water in which oatmeal has been soaked. There is no reason why some such diluent as this or something equally simple should not be tried by women employed in laundries.

There is another side of laundry life to which attention must be drawn. Laundry workers exhibit a greater liability to pulmonary consumption than women following other employments. In the Clapham Infirmary of the Wandsworth Union while 1 of every 11 laundresses was found to be suffering from pulmonary phthisis, among female patients who were not laundresses the proportion was 1 in 19; in the Isleworth Infirmary the numbers were 1 in 10 and 1 in 20 respectively. If anything were required to demonstrate the unhealthiness of laundry work and the liability to tuberculous disease created by it, reference need only be made to the writings of a French physician. Professor Landouzy, of the Hôpital Laennec, Paris, has in *La Presse Médicale*, October 6, 1905, described what is the experience of his own hospital in regard to this subject. In Parisian laundries both men and women are employed in washing and ironing. The laundresses seek hospital treatment on account of varicose veins, ulcers on the legs, and for such pelvic troubles as uterine displacements, while the men apply for relief mostly on account of hernia. Injuries and burns are frequently met with. What struck Professor Landouzy in laundry workers as compared with the other patients in the hospital was the high death-rate from tuberculosis as affecting mainly the respiratory organs. Tuberculosis was present in fully one-third of the 1,200 laundresses and female ironers, and in less than one-half of the male laundry workers. The women were affected at an earlier age than the men. The men seldom suffered before the ages of 40 and 45; the women usually at 30. In both sexes the mortality was extremely high. Out of 238 laundry workers, male and female, who died in five years in the Laennec hospital, 143 died from phthisis. More males died than females. The mortality of male laundry workers from pulmonary consumption was 75 per cent., while it was 56 per cent. among the laundresses. This is an interesting fact, seeing that the women are affected at an earlier age than the men.

To what is this high death-rate of laundry workers from tuberculosis to be attributed? We must regard as contributing causes the hard nature of the work, repeated

pregnancies, bad hygienic condition of the laundries, poor feeding, and the intemperate use of wine and stimulants, but the main cause is undoubtedly infection, to which the workers succumb often after eight or ten years of service. The strange point, too, is that it is in many instances the healthy-looking and the strong men who become affected; those who have gone about with the vans collecting the material to be washed, and who have therefore been much in the open air and lifting heavy packages, while of the women many have been robust and energetic. Such facts rather suggest that in many of the patients there had been no special predisposition to the disease, and that the contagion was caught by handling and sorting handkerchiefs which gave off, in a finely divided form, dust from dried expectoration laden with tubercle bacilli, also dust from the clothes and soiled linen of persons suffering from tuberculous phthisis. It is by the inhalation of such dried bacilliferous dust that the high mortality of laundry workers from tuberculous phthisis is to be explained. Much of this could be avoided by patients using spittoons for collecting the expectoration. No doubt in the terminal stages of pulmonary consumption the patient is so weak that he cannot expectorate into a dish, and he is therefore obliged to use something to wipe and dry his lips. Pieces of old linen that can be burned immediately after being used for this purpose are not only more cleanly, but are better and freer from risk than handkerchiefs. In addition to the danger from tubercle, laundry workers are exposed to the risk of catching other infectious diseases. Many of us have known instances of women dying of small-pox, contracted by washing the clothes of relatives who had been suffering from this disease.

A few words in regard to laundries of large Infirmaries, or in reference to laundries to which the soiled linen of large Infirmaries is sent. It has frequently happened that the sorters suffer from blood-poisoning. All infected clothing should be at once placed in a tank containing water and some such antiseptic as cyllin. Cyllin is twenty times stronger as a disinfectant than carbolic acid and it does not rot the linen like formalin, whose antiseptic powers are only

0·30 of carbolic acid. Cyllin has antiseptic properties equal to perchloride of mercury. In the "calendering" department of a laundry, *i.e.*, where the clothes are passed underneath large rollers, there is a considerable amount of steam and the work is extremely hot. Phthisis is said to be occasionally met with in the girls who follow this particular work. There is a tendency in many modern laundries to substitute for the old drying horse large drying chambers. The objection to the drying chambers is that the women have to go into the chambers, and when there are exposed to extremely high temperatures. In few occupations are the good effects of free ventilation better seen than in laundries.

Within recent years laundries have considerably improved. In May, 1907, I visited Messrs. Charvet's laundries in Paris. These are quite up-to-date, and are worked by electricity. The soiled clothes, especially shirts that contain starch, are placed in a revolving drum in which there is water containing a diastatic ferment which has the power of transforming starch into soluble sugar. It is maintained that by removing the starch the linen is made much whiter. The clothes are subsequently washed in soap and water, and afterwards in a solution of ammonia to remove the soap. The ironing of the larger and flat clothes is done by passing them under a revolving metal roller in the interior of which are gas jets kept burning, with an adequate amount of ordinary air. So complete is the combustion that, although it was towards the close of the working day that my visit was made, there was not the slightest odour of gas detected. To this circumstance and the good ventilation of the rooms I attributed the healthy look of the women in this room, as also the fact that for ironing the front of the shirts only the old-fashioned hand-iron is employed, and not the hollow hand-iron with gas jet internally. Even in such a well-conducted laundry the sorting-room is the place where there is risk to health through handling the soiled clothes from tuberculous persons. Primary disinfection of the clothes by means of formalin and steam has been tried, but the formalin was found to destroy the linen, and as a consequence the method was abandoned.

CHAPTER XV

SOLDIERS, SAILORS, AND FISHERMEN

ALTHOUGH picked men and living when on home service under favourable hygienic surroundings, soldiers have a rate of mortality different but little from that of civilians of their own age. There are few middle-aged men in the rank and file of the British Army, and while this is largely the result of the system that at present prevails, it is admitted that a soldier forty years of age is in most instances an older man than a civilian of the same age. There is an opinion that the abolition of the "sentry go" as carried out by soldiers in former years and the assumption of this duty by a special class of men known as military police will do much to lighten the burden of the young soldier and relieve him of work which was monotonous to and always disliked by him. Once a recruit has overcome the difficulties and hardships of his training, he has often, if in the infantry, more time on his hands than he can usefully employ. He has therefore often periods of enforced idleness which do not always help him physically or morally. His opportunities of smoking and of drinking are too many, and in other ways he is apt to go astray from paths that make for health. What is said of a soldier on home service applies with greater force to the soldier sent abroad. Foreign stations are not all equally healthy. The fault is not always in the barracks, but in the country itself and in the carelessness of the men in regard to drinking water outside the barrack area. Again enforced idleness, ennui, Venus, and Bacchus tell their tale, and as a consequence the death- and sick-rate of the British Army on foreign service is much higher than a

simple review of the circumstances would at first lead us to expect.

There will always be dangers to health incidental to herding together large numbers of men in barrack-rooms; but the attention that is given by military authorities to the subject of overcrowding and the fact that in almost all barracks each soldier is allowed 600 cubic feet of space have done much to diminish the mortality from pulmonary phthisis in the British Army. During the first years of the late Queen's reign the death-rate from lung diseases in the Army per 1,000 of strength was 7·82; in 1898 there were only 2·5 cases per 1,000 admitted into the hospital for pulmonary disease, and of these only a small proportion died. It is in barrack life that the good effects of ventilation have been most marked.

It is impossible in this chapter to deal at length with the diseases incidental to soldiering at home or abroad. Enteric and other fevers claim annually large numbers of our soldiers. As many of our soldiers are lost in the process of making, what I must do is to draw attention to the serious consequences that in many instances follow the hard training the young recruit has to undergo. Whether physical deterioration of the race is taking place or no we need not for the moment stop to inquire. All we know is that about half of the youths who present themselves for examination are refused on account of deficient height and weight, deficient chest measurement, and defective teeth. Of those who are accepted a certain percentage go wrong in the training. The difference effected in the raw recruit by the exercises, drill, discipline, regular and substantial meals is quickly apparent. He becomes in a few months a smart soldier with little resemblance when in uniform to his former self. It costs the country £150 for every soldier before he can be placed in the field as efficient.

Considerable discussion has taken place as to whether the physical training of the recruit is not too hard and the system faulty. Many of the recruits are young men who are out of work, whose homes are poor, and who for months or years previously have not been able to obtain always an adequate supply of food. The training therefore

should be gradual and the effects of "setting-up drill" carefully watched. The object sought to be attained in training is the improvement of the physique of the recruit, but if the following is one of the modes by which an attempt is made to attain this, opinions will be widely divergent as to its utility. Surgeon A. F. Davy, speaking of the recruit, says: "He is made to stand bolt upright, his head well back, and his chest, being dilated to the fullest inspiration, is *kept* as much as possible so dilated, an attitude useful for no kind or description of work." It is now several years ago since Surgeon Myers drew attention to the interference of the movements of the chest by tight clothing and accoutrements. Any attempt to change the shape of the chest and skeleton should be gradual. Davy says that the "setting up" or rather "breaking down" drill of the recruit starts at his first appearance on the parade-ground, with the "position of the soldier." In an interesting paper by Lieut.-Colonel H. M, Deane,[1] M.D., R.A.M.C., the whole question of the maintenance of the erect position of the soldier and his drill is fully discussed and the various drawbacks to the present methods pointed out. Attention is being directed, and not a day too soon, to the affection known as "soldier's irritable heart." For this malady the "chest advanced" posture exhibited by soldiers standing to "attention" with their chest walls fixed and the abdomen retracted so that respiration becomes extremely shallow, is to some extent responsible. Unless a man can take deep inspirations and thus send on the blood from the large veins through the right side of the heart and lungs and by full expiration assist the heart in propelling the blood into the arteries, the circulation cannot be effectively carried on. One of the results of standing to "attention" with the chest fixed in the manner just described, whereby inspiration and expiration are both impeded, is a tendency for the blood to accumulate in the right side of the heart and venous system and for less blood to pass out of the left ventricle. The pulse rate rises: it will rise from 80 to 100 per minute. In some instances after exercise in the gymnasium and when

[1] *Journal of Preventive Medicine*, May, 1906.

the position of "attention" is maintained the pulse has risen to 120 and 132. With the rapid pulse there is also epigastric pulsation, and in many of the men a diffused cardiac impulse, with absence of apical definition. Deane submits the exercise taken by young soldiers in the gymnasium to stringent criticism. He considers it to be altogether wrong. Muscular exercise tends to increase the pulse rate, but if carefully conducted there need not be signs of disordered action of the heart as a consequence. The foundation of the heart trouble of young soldiers is laid on the parade-ground, and is intensified by the exercises in the gymnasium not being conducted on physiological lines. "The mischief done to the recruit on the parade-ground can be stopped by abolishing the present position of 'attention' and giving short, plain instructions as to how to stand erect—in reality without constraint." The gymnastic staff ought itself to be properly instructed in physical training. There must be something wrong with a method of physical training which, as in the British Army, is responsible for the invaliding of such a large number of otherwise strong and healthy young men through disease of the heart and circulatory system. Since much of this arises before the soldier is sent on foreign service it is clearly traceable to conditions at home, and which experience has demonstrated to be the result of faulty physical training on the parade-ground and in the gymnasium. That the disability can be prevented is shown by the fact that when soldiers are freed from the harmful physical conditions in the Army they usually make a good recovery. We must plead for the physical training of the soldier being conducted on physiological lines. What is required of the soldier is not well developed muscle at the expense of his heart and lungs, but a healthy and well toned heart and good lungs. It is these which will help him on parade and in military marching will enable him to cover distance with little fatigue.

The Marine Service

The lot of the sailor is a hard one, and yet as a class sailors are jovial and happy men. It is only within recent

years that attention has been directed to the hygienic conditions that prevail on board ship. Too often even now the sleeping accommodation provided for seamen is not good. There is a danger, too, in damp weather of too many men congregating together in an overheated and badly ventilated forecastle and of further polluting the atmosphere by tobacco smoke. Much has been done by legislation to improve the sanitary surroundings of sailors on board ship, but there is still much to be accomplished. The good effects of the sea air obtained on deck are to a large extent counterbalanced by the overcrowding that prevails below. According to the Merchant Shipping Act, 72 cubic feet is the minimum space allowed per head, and in this space the sailor has to sleep, eat, and live when off duty. The ventilation of the sleeping cabins, like that of the forecastle, is bad, and owing to the construction of modern ships the iron and steel sweat from condensation of moisture, so that the bed-clothes in the bunks are often wet and uncomfortable. Notwithstanding these inconveniences, there are no diseases that the sailor is liable to specially attributable to his occupation. Persons become accustomed to almost anything. The sailor becomes accustomed to his frequent shifts, the intermittent character of his work, and the broken sleep. The habits thus formed in the early part of a man's life remain with him in his later years, long after he has retired from the sea. His hours of sleep are shorter than those of most people. As a reaction against the confinement on board ship, the quietude of a long voyage, and the absence of amusements except those provided by their fellow-seamen, sailors on arriving in port are apt to give way to indulgence in pleasures that often leave a sting behind. Many of their illnesses are therefore traceable to their habits when in port. Their work at times is hard, and during storms they are exposed to risks to life and to accidents of all kinds. A good many of the sailors who come to the Royal Victoria Infirmary are the subjects of thoracic aneurism, the result of hard work, sudden strain, and syphilis, also of the violent knocks and bruises to their chest received during gales. In the case of sailors who have been all the world over, and

therefore been exposed to the influence of tropical climates and to drinking contaminated water there is frequently a history of malarial, blackwater, and yellow fever, of dysentery and cholera. As a consequence, their health for long afterwards is undermined. Many of these men develop peculiar forms of bloodlessness, some of which pass into progressive or pernicious anæmia with a fatal termination. As a result of malarial fever the spleen remains enlarged for years, and long after the primary attack has passed away and the seaman lives on land he has recurrences of ague fever. Improved methods of feeding have, practically speaking, abolished scurvy, which used to be the scourge of the sea. The common diseases of sailors, such as those of the respiratory organs and heart, including rheumatism and phthisis, are partly the result of their immediate environment and insanitary surroundings, also of exposure and getting wet. The lot of the stoker on our large ships is particularly a hard one. The temperature in which the work is carried on is extremely high, so that when the ship is passing, for example, through the Red Sea and the temperature of the outside air is high and there is no aerial circulation, the men often suffer from heat apoplexy. At other times stokers run the risk of being chilled. Working with little clothing upon them, they often come out of the hold in a state of extreme perspiration to get a breath of cooler air, but the practice is not free from danger. That much can still be done to improve the health of the ordinary sailor and diminish risk to life and limb through accident, is shown by the difference in men following the same vocation but under different conditions. In the merchant service the mortality rate from all causes for 1898–99 was 9·60 per 1,000, while for 1899 the corresponding rate in the Royal Navy was 4·91 per 1,000, or about one-half. The mortality figures of 9·60 per 1,000 in the mercantile marine were made up as follows: 7·4 from injury and 2·2 from disease. The 4·91 per 1,000 of the Royal Navy were compounded of 3·56 from disease and 1·35 from injury. These figures speak for themselves. Probably some lives would be saved in the mercantile marine service were medical and surgical aid more readily available. The officers of steam and sailing

ships ought to have some practical knowledge of ambulance work.

Of the vocation of the fisherman little need be said. Like that of the sailor, the occupation is one attended by great risk to life from sudden squalls, dangers to health from exposure to inclement weather, occasionally long hours and irregular meals. Fishermen are liable to many minor accidents, neglect of which is often followed by blood-poisoning.

CHAPTER XVI

RESCUE WORK IN MINES

EXPERIENCE and statistics show that while the occupation of the coal-miner is not *per se* an unhealthy one, the risks attendant upon his calling are such as to render coal getting one of the most hazardous occupations man can follow. It is only when some great calamity occurs that the public realises this fact. The appalling catastrophe at Courrières, in France, on March 10, 1906, whereby the lives of 1,100 men and boys were lost, created widespread interest in and sympathy for a class of men who in the hour of danger are known to be capable of performing deeds heroic and altruistic. No sooner had the sad news passed from one country to another than Germany, in her desire to show practical sympathy with the French people and her eagerness to have rescue apparatus practically tested, volunteered to send trained men to assist in rescuing the entombed miners, an offer which was as gratefully accepted as it was generously made. It was an example of a great nation offering to another in its hour of distress the application of science to the saving of human life. The loss of such a large number of human lives has again revived in our own as in every coal-producing country the question as to the best means to be adopted for the rescue of miners imprisoned in a coal-mine after an explosion. In this matter Great Britain ought to lead the way. As to the causes of colliery explosions little need here be said beyond the fact that colliery owners and officials are gradually coming round to an acceptance of the opinion that explosions are in many instances due to the ignition of fine coal dust in

a dry part of a mine. Gas is the enemy of the coal-miner; so, too, is dust. When mention is made of "mine gas" or "gas" in a mine it is methane, marsh gas, or what is popularly known as "fire-damp," that is meant. Although the gas does not support combustion, it is itself combustible and burns with a blue flame. It is a product of the decomposition of organic substances, especially of vegetable fibre, in the absence of air but in presence of water. The gas is pent up in the coal frequently under such high pressure that it issues from the pores of the coal with a crackling noise well known to the miner. Mixed with oxygen, methane forms an explosive mixture, to which the term "fire-damp" ought only to be applied, and not to methane itself. The other dangerous gases are carbon monoxide, generated in an explosion, and the less poisonous carbon dioxide. In a colliery explosion miners may be killed either by the severe shock or by the flame, as the extensive burning of the body shows, but the largest number fall victims to the carbon monoxide gas which accompanies the hot column of air that has been generated. When an explosion occurs there is at first an enormous expansion of the air in the particular gallery of the mine, consequent upon the production of hot gases. This is followed by a rapid shrinking. The hot gases pass along the path of least resistance, and having undergone combustion their volume is less than previously. Marsh gas when exploded is found to have undergone a diminution of two-thirds of its volume after condensation of the moisture produced. An explosion in a coal-mine is followed by an enormous rise of temperature, to 300° F. and higher. Upon the bodies of the miners who have been killed in a colliery explosion the effects of two different causes are observed. There are wounds that have evidently been produced from without inwards and are due to the enormous pressure of the gases at the time of their combustion, and there are wounds produced from within outwards during the cooling of the gases. These latter wounds are only met with upon the bodies of men who had been working a short distance from the seat of the explosion in a gallery that was a cul-de-sac or where falls had occurred.

Thus are explained the ecchymoses and multiple injuries or wounds from without inwards, and the shattering and disruption of the body when the wounds have been produced by causes operating from within outwards. In the blood of miners killed in this manner there is no trace of carbon monoxide on spectroscopic examination. Many of the miners are killed by the column of gas suddenly striking them with all the force of a projectile. It is this shock or sudden impact that kills, frequently tearing asunder the limbs from the body and hurling them yards away. That men thus killed had died suddenly is proved by the absence of the spectrum of carbon monoxide in their blood. Where the corpses exhibit marks of burning it might, under certain circumstances, be desirable to know whether the burns occurred before or after death. Miners who perish in an explosion from an expansion of the flame are not really burned in the ordinary meaning of the word; it is more a singeing than a burning. Brouardel, in speaking of such cases, says the burns are not all serious, but as the air contains a large quantity of coal dust which becomes encrusted upon the skin of the body, the corpses are black and appear as if badly burned. Most of the burns on the body are the result of the hot air. In the Courrières mine [1] there was little flame—any that there had been was of short duration; for while the clothes of the miners were not burned the underlying skin of the body was singed. It was therefore difficult to make a distinction between the bodies of miners who had died from burns and dead bodies which had been subjected to the action of fire. The burnt corpses were those of men who had either been burned by the hot gases or had been killed by carbon monoxide before the arrival of the flame. It is very improbable that any absorption of carbon monoxide gas occurred after death. In another part of this book I deal with this subject. Here I need only say that in none of the bodies of dead animals exposed even for a week to carbon monoxide gas did I find that absorption of the gas had taken place.

[1] *Annales d'Hygiène*, publique et de Médecine Légale, Novembre and Décembre, 1906, Etude Medico-Légale de la Catastrophe de Courrières. Dr. Firmin Dervieux, Paris.

The largest numbers of deaths in the Courrières mine were due to carbon monoxide poisoning. Several of the bodies of the dead miners were found in the position in which the men had been working when death suddenly overtook them. The force of the explosion had driven before it a column of gas containing carbon monoxide, and as this gas became cooled on its course along the galleries it immediately poisoned the workers who inhaled it. When death takes place through inhalation of air containing a high percentage of carbon monoxide gas convulsions do not occur. The features are perfectly placid. It is in slowly induced intoxication by carbon monoxide that the locomotive powers become enfeebled. Of the occurrence of this there was evidence in some of the miners at Courrières; for the men, feeling that there was something wrong with the air they were breathing and probably experiencing headache and vertigo, had tried to save themselves, but as the gas travelled more quickly than they were able to walk it overtook and poisoned them.

I have taken as the basis of my remarks for this chapter the mine catastrophe at Courrières because it is the greatest mining disaster of recent years. It is said that one of the most painful circumstances to the relatives of the deceased miners was the difficulty of recognising the bodies owing to the injuries and putrefaction. In the mine itself one of the most trying circumstances the rescue men had to deal with was the rapidity with which putrefaction of the dead bodies had occurred, the unpleasant and repellent odour that prevailed, and which made rescue work a peril to the health of all who attempted it. Some of the wounded miners who were brought to bank only lived a few days. Most of them died from pneumonia, either due to having respired the hot air in the mine—which is scarcely likely, for death would probably have come more quickly—or as the sequel of carbon monoxide poisoning. Dr. Lourties states that several of the miners died from pneumonia 50 to 60 hours after being rescued. The inflammation of the lungs in each instance developed with great rapidity, and was accompanied by a high temperature. The pulmonary lesions, which were

extensive, were lobar and not lobular. There was a greater tendency for the right than the left lung to be involved, probably owing to the fact that the right bronchus is larger than the left. That several of the rescued miners who suffered from pneumonia had breathed carbon monoxide gas in the pit their own statements amply confirmed. The invalids stated that they had felt headachy and dizzy, and had been overcome by a drowsy, sleepy feeling. A few of the men, too, became paralysed in their limbs.

To enable firemen to enter premises filled with smoke and irrespirable gases, also rescue parties to descend into a mine after an explosion, several forms of respiratory apparatus have been recommended. When an accident has occurred in the down-cast shaft of a pit, as happened a short while ago at Boldon Colliery, near Newcastle-upon-Tyne, whereby, owing to a break in the rope, the cage suddenly dashed to the bottom of the shaft, killing its three occupants, the only entrance into the mine is by the up-cast shaft, or that up which the foul air of the mine is passing along with smoke from the furnace at the foot of the shaft. This shaft, required by law in all pits, is nothing else than a wide smoking chimney. In descending the up-cast shaft it is almost impossible to breathe owing to the thick and poisoned air, and as the lower part of the shaft is reached the heat becomes intolerable owing to the proximity of the furnace. It was a Sunday morning when the accident occurred at Boldon Colliery, and there were therefore no men in the pit, except those who had gone down in the cage that morning. Dr. O'Kelly, of Boldon Colliery, with two mining officials entered the mine by the up-cast shaft. The air was stifling and hot. The descent was of such a nature as ought only to have been made by men wearing each a safety respiratory apparatus. In the absence of such, Dr. O'Kelly and his comrades applied a wet handkerchief over their mouth and nostrils, and by this means they withstood the choking influence of the sulphurous vapours given off by the burning coal at the bottom of the shaft. Many forms of respiratory apparatus have been recommended. Rescue work in mines is work upon which physicians, chemists, mining engineers,

and colliery officials can bring to bear the united influence of the allied sciences. One of the greatest difficulties rescue parties have to encounter is the extremely high temperature in a mine after an explosion. This, while a serious difficulty, ought not to be insurmountable. Science has already accomplished much in the saving of human life; it will yet do more.

In 1846 Sir Henry T. de la Beche and Dr. Lyon Playfair reported that after a colliery explosion there was, but for carbonic acid, a sufficient quantity of oxygen present in the mine to support life where men had survived the immediate effects of the explosion. Three years afterwards Dr. John Hutchinson proposed that an exploring party should carry bags containing air into the mine, so that they might exist for half an hour. In 1880 Henry Fleuss invented an apparatus which was used with some success at Seaham Colliery in the following year. Twelve months afterwards David Rhys Jones showed that oxygen could be used for rescue work in mines. In the early experiments men were provided with a tube which they placed in their mouth, or it was fixed to the helmet, and through this tube atmospheric air was pumped from without, as in the case of divers, but the disadvantages of such a method are that the tube might become kinked, and owing to the distance the men might have to travel the tube would become extremely heavy. It is, therefore, necessary to have an *autonomous* respiratory apparatus which will enable a man to carry with him a sufficient quantity of air to render him independent of the atmosphere immediately urrounding him, and which at the same time shall cut him off from the possibility of inhaling dangerous gases. When compressed air was first tried it was found that men could support themselves in a poisonous atmosphere for twenty minutes. Since then many improvements have been made in the forms of respiratory apparatus. On the Continent, one of the pioneers of the movement is Dr. Guglielminetti, whose experience as an aeronaut and an Alpine climber enables him to speak with some authority as to the value of compressed oxygen, and whose invention has been adopted

by the Draegerwerk at Lubeck. Atmospheric air contains in volumes 79·04 nitrogen, 20·93 oxygen, and carbonic acid 0·03, while expired air contains 79·6 volumes of nitrogen, 16·04 oxygen, and 4 of carbonic acid. About the same quantity of carbonic acid is given off as there is of oxygen absorbed. There is a mutual interchange between the two gases. A man requires not less than 500,000 cubic inches of air per 24 hours. In other words, he gives off per hour half a cubic foot, or 864 cubic inches, of carbonic acid and the same quantity of oxygen is absorbed. Any person attempting to do rescue work should therefore be provided with not less than 1 cubic foot of oxygen per hour. Mr. W. E. Garforth,[1] Altofts Colliery, Normanton, who has given considerable attention to the practical study of this question, says that "if a workman had given to him a cylinder containing 3 cubic feet of oxygen at atmospheric pressure for the outward journey, and a cylinder containing 3 cubic feet at atmospheric pressure for the return journey, he would under any circumstances, unless there was great waste, have sufficient oxygen to last for 2 hours, even if during that time he underwent considerable exertion." In the respiratory interchange of gases in the human body nitrogen plays no part. The gas is quite inert, and this is one of the reasons advanced for not using compressed atmospheric air in rescue work, since, nitrogen being lighter than oxygen, would be the first gas to be given off; also, in order to carry a sufficient quantity of respirable gas, the weight of the apparatus would be considerably added to by the nitrogen, which, after all, is of no special use, since it plays a purely passive part in respiration. By eliminating nitrogen the apparatus can be reduced to one-seventh of its original weight. In a demonstration given at the Institution of Mining Engineers, Newcastle-upon-Tyne, Mr. Otto Simonis[2] showed how the "aerolith," a liquid-air rescue apparatus, could be employed in mines after an explosion. The entire apparatus weighs

[1] "A New Apparatus for Rescue Work in Mines," *Transactions of the Institution of Mining Engineers*, June 14, 1906.

[2] *Transactions Mining Engineers*, 1906, "Liquid Air and its Use in Rescue Apparatus."

14 lbs., "is easily carried on the back without any encumbrance, and it gives an absolutely pure and deliciously cool air-supply for up to three hours' working. It does not contain any chemicals; it is without any complications whatsoever; there is not a single valve in the whole apparatus, and its use does not require any special training. Atmospheric air liquefies at a temperature of $-191°$ C. and is compressed to about the seven-hundredth to eight-hundredth part of its original volume. Consequently 1 gallon of liquid air will evaporate into 700 to 800 gallons (110 to 130 cubic feet) of atmospheric air." When fully charged the entire apparatus weighs 24 lbs. Liquid air contains 2 parts of oxygen to 1 part of nitrogen. Simonis claims for his apparatus, that the fresh air-supply is always ample, that it is absolutely pure, and that it can be stored in the vacuum vessels designed by Sir James Dewar, but losing from 5 to 10 per cent. by evaporation per day. Liquid air can be produced at the rate of threepence per gallon and upwards, according to the size of the plant.

In respiration only 4 per cent. of the oxygen inhaled is taken up by the blood passing through the lungs; the remainder is exhaled without being utilised. To replace this loss of oxygen there is added to the exhaled air 4 per cent. of carbon dioxide. With physical exertion the amount of CO_2 is increased. It is this gas which, when it accumulates in too large a quantity, becomes a source of trouble, and has therefore to be removed. When present beyond 1 per cent. it causes headache and a sense of distress. In all forms of rescue apparatus, therefore, provision is made for the absorption of the carbon dioxide by passing it through a series of tubes containing a solution of caustic potass. The air thus purified passes further on through the apparatus, where at a particular part it meets and mixes with the oxygen coming from one of the cylinders. In all forms of rescue apparatus the oxygen should escape from the cylinder automatically into a tube going to the mouth-part of the helmet worn by the miner. The air that has been breathed becomes hotter: at the increased temperature it becomes a source of inconvenience and uneasiness to the wearer of the apparatus.

Means are therefore provided in the apparatus for cooling the air by passing it through a refrigerator. That the CO_2 of the exhaled air is really absorbed in the potass tubes is confirmed by the analyses made by Gréhant, who found no trace of the gas in the apparatus used by the German miners at Courrières.

On November 29, 1905, at the School of Mines, Bochum, Westphalia, an examination of the various forms of apparatus was made by a commission appointed by the Board of Administration of the Mines at Dortmund. Of the various forms of apparatus tried the Giersberg, Meyer, and Guglielminetti-Draeger, it was found that the men who used the Draeger were not at all fatigued when they came out of the artificial mine. If a rescue apparatus is to be of any help to men exposed to a poisonous atmosphere it ought to be easy of application and adapted to meet the requirements of the body; it should not be too heavy, nor so cumbersome as to prevent a miner passing over rough ground or crawling on his hands and knees through narrow spaces, nor should the apparatus in any way compress the chest-wall of the wearer and impede his respiration. The wearing of it should neither cause distress nor be attended by difficulty or rapidity of breathing. The eyes of the miner must be protected from irritating smoke and gases, but they must not be so dimmed by the protecting surface that the individual cannot see sufficiently. It is an advantage to have the ears clear and open, so that sounds and cries of distress or for help can be heard. Opinions are divided as to the desirability of wearing a helmet. It is safer. The apparatus should be provided with two cylinders of oxygen, so that the rescuer might be capable of staying in the mine at least two hours, and it should be of such a design as not to restrict the movements of the limbs. The expired air must be passed through caustic potass to have the carbonic acid removed, and also through refrigerators to be cooled. Above all the apparatus must be trustworthy and be in perfect order, so as not to play false in the moment of danger. To be on the safe side, and in order to allow of heavy work being done, a man about to undertake rescue work should be given a continuous supply of two litres

(122 cubic inches) of oxygen per minute. Too much oxygen must not be supplied, as it causes dryness of the throat. Nearly all the forms of rescue apparatus are designed on the same plan. It is desirable that the apparatus should be capable of being put on and taken off by the wearers themselves, also that men should be practically trained as to its use, so as to overcome the nervousness which is invariably observed in those wearing the apparatus for the first time. Mine managers and mining officials are of the opinion that there is as yet no ideal rescue apparatus in the market, but the vast strides that have been made in this direction within recent years show that many difficulties have already been surmounted, that there is every prospect of a more perfect apparatus being reached, and to accomplish this British inventors are doing their part. A few years ago it was proposed by the Midland Institute of Mining, Civil, and Mechanical Engineers to establish rescue stations, at which men might be trained in the use of life-saving apparatus in colliery explosions. In 1899 Mr. W. E. Garforth, of Altofts Colliery, Normanton, arranged for the construction of an artificial gallery in which experiments might be carried on. I have had, through the kindness and courtesy of Mr. Garforth, the opportunity of witnessing some of these experiments. At Messrs. Pope, Pearson & Co.'s collieries four men have been undergoing training in the gallery. The gallery is 150 feet long and forms three sides of a square; it is 6½ to 7 feet high and is air-tight. It is provided with windows, through which the experiments can be watched. A successful effort has been made to make the interior of the gallery resemble as far as possible the galleries of a coal-mine that have been wrecked after an explosion, where the floors are covered with débris, timber has been broken and blown out of its place, the roof fallen in here and there, so as to make walking impossible. Into this gallery, which is filled with smoke and noxious fumes from burning sulphur, timber, leather, &c., the men, wearing an apparatus of Mr. Garforth's own device, enter. Each man is provided with a double cylinder of oxygen and an electric lamp. The men work in couples, and they have to encounter the physical difficulties

that are likely to be met with in a coal-mine after an explosion, including the presence of poisonous gases. They have also to extinguish a fire and to bring out of the gallery a dummy, a supposed injured or dead miner, weighing 160 lbs. I saw these men, wearing the apparatus on their back, crawl on their knees over as rough surfaces as any likely to be met with in a wrecked mine, extinguish a fire and bring out a dummy miner which they had themselves brought through a broken iron pipe 18 inches in diameter, also pulled and pushed it over rough falls of stone. In the three hours during which the men were in the artificial gallery they walked and crawled a distance equivalent to two and three-quarter miles; they also performed all kinds of hard work.[1]

In the earlier experiments carried out by Mr. Garforth, Drs. T. Marshall Nicholson and A. Mackenzie, of Leeds, recorded the pulse rate and temperature of the men before entering and again on coming out of the gallery. With the physical work it was found that the rate of the pulse increased and there was a rise of the body temperature from 1° to 2° F. The men complained of headache, which in half an hour disappeared, also of nausea and giddiness, and it was observed that they were cyanosed in the face owing to the congestion of the blood-vessels. Since that date Mr. Garforth has considerably improved his apparatus, known in the trade as the "Weg," and with it even after prolonged tests there are no longer complaints by the men of headache, nausea, or feeling of sickness. The men come out of the gallery after three hours' hard exercise fresh and fit for other work. The total weight of the "Weg" apparatus is 21 lbs. 5 oz.

A series of experiments carried out by men wearing the Draeger apparatus has been equally successful. The men emerged from the gallery after having performed arduous work for two and a quarter hours without signs of fatigue. It was shown too that the men wearing the Draeger were capable of lifting a greater number of pounds weight in a given time than with some of the other forms of apparatus. For a full description of this apparatus and its power of

[1] *Transactions of the Institution of Mining Engineers*, vol. xxii. 1901–1902.

removing CO_2 from the exhaled air see pamphlet "Tests of Life-saving Apparatus," by H. and B. Draeger, Lubeck.[1]

The Director-General of the Society of Mines at Lens, France, informs me (August 7, 1907) that several experiments have just been made in the mines at Lens with the safety apparatus invented by Dr. Tissot, which he regards as superior to the other forms of apparatus that have hitherto been tried. Two coal-miners wearing the "Tissot" safety appliance were able without any previous training or experience of the apparatus to penetrate into the various parts of the mine for three hours, and when there to undergo work of such an extremely fatiguing nature as had been found to be impossible in experiments with other forms of apparatus. The apparatus is of the same type as the "Weg."

Through the kindness of Major Cardier I have had the opportunity of seeing the firemen at one of the barracks of the Sapeurs-Pompiers, Paris, demonstrate the applicability of the rescue apparatus invented by one of their officers, Lieutenant Vauginot. One of the peculiar features of the apparatus is the warning given by a shrill whistle when the compressed air is almost played out. Two cylinders of compressed air are carried; these together last forty minutes. The expired air escapes by a valve below the helmet. The apparatus weighs 32 lbs. The Vauginot appeared to me to be useful for firemen going into a building filled with smoke or poisonous vapour for a short period.

If rescue work in mines after explosions is to be carried out on sound practical lines and on scientific principles, there ought to be training stations in different parts of the country. The subject is one to which medical men engaged in colliery practice, also casualty surgeons to police authorities, should give attention. Training in rescue work ought to form part of the ambulance instruction given in mining centres. If young men who are being educated for the higher appointments in mining were also trained in rescue work, the instruction would be invaluable to them, since they will be the mine managers of the future.

[1] Obtainable from R. Jacobson, 11, Water Lane, Great Tower Street, London, E.C.

To get to the entombed miners is one of the difficulties in rescue work, owing to the high temperature, and another difficulty is the removal to a place of safety of miners found alive. By a rescue party an extra number of masks would have to be carried, which could be placed on the face of the men who when found show signs of life, oxygen supplied, and its entrance into the lungs secured by artificial respiration; in addition efforts would have to be made to bring the miners to the surface as soon as possible. Much yet remains to be done before rescue work by men wearing special respiratory apparatus can be regarded as perfectly safe. In Austria fatalities have occurred to men wearing these, but only when the appliance has been of the type in which reliance is placed upon chemical decompositions being effected and oxygen liberated, and not when the men have been carrying small cylinders of oxygen in the manner detailed above.

Any doubts held by colliery managers as to the practicability of the use of rescue apparatus in mines after explosions, if not removed by the Garforth and other experiments alluded to in the text, ought to be by the results obtained under the following circumstances:—On Sept. 14, 1907, an explosion occurred in the "Saar" and "Mosel" Colliery at Merlbach in the Prussian Saar district. A rescue party of twelve men, equipped with the Draeger apparatus, descended, and, after working for an hour, brought to the surface the eight survivors and the bodies of four men who had been killed by the explosion. Vide *Iron and Coal Trades Review*, Sept. 27, 1907.

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